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Tawny Dragon (*Ctenophorus decresii*) from near Broken Hill, New South Wales  
(Photo: S. Sass). See article on this species on page 52.

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# NOTES ON DIET AND REPRODUCTIVE CONDITION OF *CTENOTUS* (SCINCIDAE) OF THE MALLEE OF SOUTH AUSTRALIA

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## INTRODUCTION

Pianka (1969, 1986) was the first to point out the high degree of sympatry in the Australian desert skinks of the genus *Ctenotus*. Several detailed studies have built on his work, investigating niche and niche partitioning. Most work on *Ctenotus* ecology has focussed on the lizard fauna of the sand dune deserts of Central Australia (James, 1991a,b; Twigg *et al.*, 1996). A number of studies (Davidge, 1980; Taylor, 1985, 1986; Henle, 1989; Archer, 1990; Brown, 1991; Coventry, 1996; Read, 1998; Taylor, 2004; Craig, 2006, 2007) have examined the ecological communities of arid and semiarid southern Australia, which experience cooler conditions with more regular rainfall compared with the Great Victoria Desert and Central Australia. However, few studies have examined communities in semi-arid mallee woodlands of South Australia.

In South Australia, semiarid mallee woodlands characterise a broad belt across the southern inland, generally contained between the 250 and 500 rainfall isohyets. This habitat type contains a high diversity of lizards, with six *Ctenotus* species, *C. atlas*, *C. brachyonyx*, *C. taeniatus*, *C. orientalis*, *C. regius* and *C. schomburgkii*, commonly found to occur in various combinations. The Nullarbor Plain marks a break in the southern mallee belt, and the eastern mallee region supports a markedly different suite of species to that of the mallee in the south and south-west of Western Australia (Storr *et al.*, 2000).

The present study is part of a larger study aimed at extending knowledge of sympatric *Ctenotus* of southern semi-arid Australia. The aim of this study was to investigate the diet and reproductive condition of these species based on specimens in the collection of the

South Australian Museum, Adelaide (SAMA). This will assist in the further understanding and investigation of the sympatric associations of the *Ctenotus* skinks in the southern mallee region.

## METHODS

Specimens of six species lodged in the South Australian Museum collection that had been collected in the course of biological survey work between 1974 and 2002 were used in the analysis of reproductive status and gut content: *C. atlas* ( $n = 32$ ), *C. brachyonyx* ( $n = 34$ ), *C. taeniatus* ( $n = 35$ ), *C. orientalis* ( $n = 32$ ), *C. regius* ( $n = 57$ ) and *C. schomburgkii* ( $n = 34$ ). Some species (*C. taeniatus*, *C. regius* and *C. schomburgkii*) are found widely across central Australia, and to make the specimens selected representative of the mallee habitat, we restricted our selection to specimens collected from South Australia south of 32°S.

The specimens (formalin fixed and stored in 70% ethanol) were dissected with a mid-ventral incision, stomachs removed and SVL measured (mm). Stomachs were dissected and contents were identified to order for arthropods, with other categories created for non-invertebrate remains (plant material and skink remains). Stomach contents were scored qualitatively (present or absent) for each individual, and the largest prey item size (mm, by largest dimension) was noted for each specimen. The proportion of individuals consuming each prey type was calculated to indicate the relative importance of each prey type in the diet of each species. "Main" prey items were identified using one of the criteria specified by James (1991a), where more than 20% of individuals of a species must have consumed the prey category.

Sex and corresponding reproductive state were recorded through visual inspection of gonads. Males were recorded as immature (testes small and undeveloped) or as mature (enlarged testes) with the right testis length (mm) measured as a gauge of reproductive stage. Females were recorded as immature (undeveloped oviduct), mature but not breeding (oviduct developed, but empty), or mature and breeding, with the number of enlarged yolking ovarian follicles or oviductal eggs noted to estimate clutch size.

## RESULTS

### Diet

Stomach contents of the six *Ctenotus* reflected a generalist insectivorous diet. The relative proportion of individuals consuming all prey items is shown in Table 1. All species exam-

ined appeared similar in diet, with hymenopterans among the most common prey items for all species and these were almost exclusively ants, particularly alate ants. In the stomach of one *C. regius*, 20 - 30 alate ants (Formicidae: *Pachycondyla*) were found, indicating that this individual had opportunistically fed on these ants during their nuptial flight. Several *C. schomburgkii* individuals contained the abdomens of dolichoderine ants (probably *Iridomyrmex*, A. McArthur, pers. comm.), each 5 mm long, a large meal for a small lizard such as *C. schomburgkii*. The almost complete absence of any other appendages or body segments of these ants indicates that the abdomens of these ants may be selectively 'harvested' by *C. schomburgkii*.

Termites were only considered a 'main prey item' for *C. schomburgkii* and *C. orientalis*,

**Table 1. Summary of stomach contents of *Ctenotus* specimens. Entries marked \* are the "main" prey items (James, 1991a), those where >20% of the individuals of at least one species contained this item.**

Taxon	Percentage (%) of individuals containing prey items					
	<i>atlas</i> (n = 34)	<i>brachyonyx</i> (n = 32)	<i>orientalis</i> (n = 32)	<i>regius</i> (n = 57)	<i>schomburgkii</i> (n = 34)	<i>taeniatus</i> (n = 35)
Araneae	*20.6	6.3	18.8	15.8	14.7	17.1
Blattodea	---	---	---	---	5.9	---
Coleoptera adult	*20.6	12.5	*21.9	*33.3	*20.6	17.1
Coleoptera larva	---	18.8	---	---	---	---
Dermoptera	5.9	---	---	3.5	5.9	---
Hemiptera	*32.4	*25.0	*25.0	12.3	11.8	14.3
Hymenoptera	*20.6	*25.0	*21.9	*33.3	*29.4	*25.7
Isoptera	2.9	3.1	*37.5	14.0	*32.4	11.4
Lepidoptera larva	2.9	---	---	---	---	---
Orthoptera	*41.2	*21.9	9.4	*31.6	5.9	2.9
Pseudoscorpion	---	---	---	1.8	---	---
Scorpion	---	3.1	---	1.8	---	---
Seed/plant material	---	9.4	18.8	*31.6	---	---
Vertebrate (lizard)	---	3.1	3.1	1.8	---	---

forming a less important role in the diet of the other *Ctenotus* species examined (Table 1). The termites consumed by *C. schomburgkii* and *C. orientalis* were identified as *Amitermes* sp. and *Nasutitermes* sp., while *C. taeniatus* only consumed termites of the genus *Coprotitermes* (Rhinotermitidae).

The larger three species, *C. regius*, *C. brachyonyx* and *C. orientalis*, were the only species to consume plant material and vertebrates. Plant material, particularly large fleshy seeds, was commonly consumed by over 30% of *C. regius* specimens examined. Skink remains were found once each in *C. regius*, *C. brachyonyx* and *C. orientalis*. In two cases (*C. orientalis* and *C. regius*), the remains consisted of a complete individual of the small skink, *Menetia greyi*, while the third instance was the autotomised tail of a small skink, probably *Morethia* sp. Coleopteran larvae were a frequent prey item for *C. brachyonyx*, but were not present in any other species. Coleopteran larvae, a cryptic food item, may

reflect different foraging techniques employed by this species.

The size of prey items proportionate to SVL was measured, with a frequency histogram shown in Figure 1. This shows that items between 4 and 8 percent of SVL were most frequently the largest items consumed by lizards, or that larger items were less commonly encountered. However, the largest items measured are not necessarily intact organisms due to the fragmentation of prey when consumed, so the histograms will to some extent understate the maximum size range of prey.

### Reproductive condition

The reproductive patterns of these *Ctenotus* species are shown in Table 2. Mature females were always larger (SVL) than mature males, with the minimum size at maturity of each sex shown in Table 2. Clutch size was generally two to three. However one *C. orientalis* female was found to contain six enlarged,

**Table 2. Summary of reproductive patterns of *Ctenotus* specimens. Numbers in brackets (n) indicate the sample size of males and females examined; in total (size range), the number of mature specimens (minimum size of maturity), and the number of gravid females (clutch size).**

<i>Ctenotus</i> species	Size range (SVL, mm)		Minimum size of maturity (SVL, mm)		Clutch size (n)	Time of egg production
	Male (n)	Female (n)	Male (n)	Female (n)		
<i>atlas</i> (n = 34)	36-65 (23)	38-75 (11)	55 (21)	63 (8)	3 (1)	Dec
<i>brachyonyx</i> (n = 32)	46-81 (16)	39-86 (16)	69 (13)	65 (15)	3 (1)	Jan
<i>orientalis</i> (n = 32)	49-74 (22)	43-74 (10)	62 (14)	62 (7)	2-6 (2)	Nov-Dec
<i>regius</i> (n = 57)	42-72 (31)	44-76 (26)	56 (26)	57 (21)	3-4 (3)	Nov-Jan
<i>schomburgkii</i> (n = 34)	36-46 (20)	32-49 (14)	36 (20)	38 (13)	2 (5)	Oct-Dec
<i>taeniatus</i> (n = 35)	27-49 (20)	26-52 (15)	37 (15)	39 (9)	2 (3)	Oct-Nov

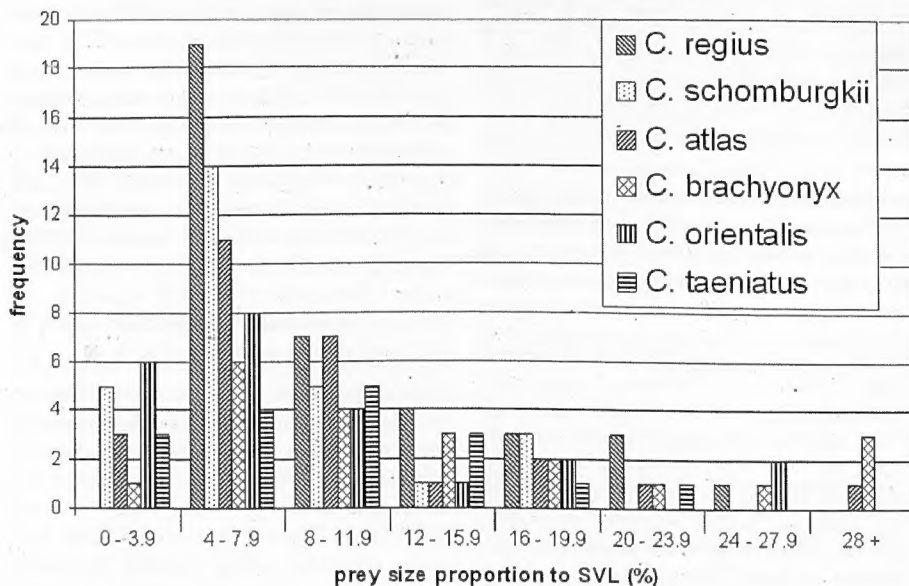
yolked ovarian follicles that were all of equal (maximum) size. Clutch sizes in at least *C. orientalis* and *C. regius* were not fixed, and may be influenced by size and/or age, as the largest clutches were produced by the largest individuals within each species. Time of reproduction was similar amongst all species, with enlarged, yolked follicles or oviductal eggs found from late October to January. Male testis length (both actual length, and length proportional to SVL) peaked between October and December, but the patterns in our small samples were irregular. In *C. regius*, *C. schomburgkii* and *C. brachyonyx*, testis length increased towards December, where it reached a maximum. By contrast, testis length for *C. atlas* and *C. orientalis* was at a maximum in October, and declined by December. Testis length for *C. taeniatus* fluctuated over spring and summer, peaking in September and November. These trends should be treated with caution because of the lack of available specimens to provide information on reproductive condition over winter

and early spring, and the fact that specimens are derived from different localities in different years.

## DISCUSSION

The *Ctenotus* species of the southern mallee region that we examined had unspecialized, mainly insectivorous diets and opportunistic foraging, as has been generally found in other studies of *Ctenotus* skinks (Pianka, 1969; James, 1991a; Read, 1998). There were few differences in the range of items composing the diet of these six species of *Ctenotus*, but these prey items varied in frequency among the species. The opportunistic nature of the diet is also shown by comparing the markedly differing dietary compositions of *C. orientalis* in our study and that of Coventry (1996). Items such as cockroaches, chilopods, caterpillars and molluscs that were absent in our study, were found in *C. orientalis* (as *C. uber*), from heathy mallee habitat in Victoria (Coventry, 1996). Diet of *Ctenotus*

**Figure 1. Frequency of prey item size, proportionate to SVL (mm), consumed by mallee *Ctenotus* species.**





is known to vary considerably with prey availability and seasonal conditions (James, 1991a), which may contribute to these differences, in addition to differences in locality.

Compared to the diets of Central Australian populations of *Ctenotus*, our mallee sample was notable for the consistently moderate importance of termites, and the relatively high incidence of ants. The importance of termites in the diets of *Ctenotus* species of the Great Victoria Desert has previously been outlined by Pianka (1969) and further investigated in central Australia by James (1991a). Termites were found as a main prey type for all five *Ctenotus* species studied by James (1991a), with consumption varying from 0.14 (*C. piankai*) to 0.91 (*C. pantherinus*) of individuals. However, our study found a reduced role of termites in the diets of most *Ctenotus* species of the southern mallee, with consumption varying from 0.031 (*C. brachyonyx*) to 0.375 (*C. orientalis*).

The termites consumed in our study were identified as being *Amitermes*, *Coptotermes* and *Nasutitermes*, with up to six termite genera consumed by some species. Of these, *Amitermes* and *Nasutitermes* were also found as prey by James (1991a). While the diversity of termite species in the southern semi-arid mallee is relatively unknown, the consumption of termites by these lizards suggests that while termites are potentially available within this environment, not all species make great use of them. The two species with the lowest incidence of termites are *C. atlas* and *C. brachyonyx*. These are the largest species, and also the two most closely associated with life in and around *Triodia* hummocks. Different foraging techniques or a difference in microhabitat may therefore partly explain the differences between species.

Hymenopterans were a main prey item in all of our species. *Ctenotus* of central Australia consumed ants less frequently, forming a main prey item in just one (*C. leonhardii*) of five *Ctenotus* species studied by James (1991a). Even studies of more southerly *Ctenotus* by Read (1998) did not report the

consumption of ants (hymenopterans) by either *C. schomburgkii* or *C. orientalis* (as *C. uber*), but this is most probably due to the methods used (simple observation) and the low sample size of that study. Consumption of ants may be opportunistic due to the high numbers of alate ants found.

The consumption of plant material and seeds by the larger *Ctenotus* species (*C. orientalis*, *C. regius* and *C. brachyonyx*) is consistent with reports of *C. orientalis* and *C. regius* actively foraging on berries and leaves of saltbush (*Enchylaena tomentosa*) (Bedford, 1992; Brown, 2003). This provides further support for an opportunistic, active foraging strategy for these *Ctenotus* species.

Our findings support those of Pianka (1969), with larger species consuming larger prey items than smaller species. However, these trends must be interpreted conservatively because fragmentation of prey (when consumed by the lizards) may underestimate the representation of larger prey items. In nutritional terms the few large items may be rare, but may contribute disproportionately to caloric intake.

Few differences in reproductive patterns were found overall, with the time of reproduction ranging from early spring through to late summer (Table 2), which generally corresponds with the time of reproduction reported for central Australian species. The time of ovulation of *C. regius* in our study corresponds with that found by Henle (1989), and *C. schomburgkii* corresponds with that found by Read (1998). Although James (1991b) found double clutching to be common in the lizard community of Central Australia, we were unable to detect double clutching due to the small sample sizes in our study.

Read's (1998) study of southern *Ctenotus* found smaller clutch sizes than those reported for *Ctenotus* of central Australia (Pianka, 1969; James 1991b). The clutch sizes in our study are closer to those found by Read (1998) near Olympic Dam in arid South Australia, providing further evidence of smaller



clutch sizes in more southern *Ctenotus* populations. Variation in clutch size did occur in *C. regius* and *C. orientalis*, which may have been influenced by maternal size and/or age. James (1991b) found, on average, clutch size increased by one egg for every 12 mm of SVL. While this may explain the variation in clutch size found in *C. regius*, the one individual of *C. orientalis* that contained six eggs was only 8 mm larger than the other gravid female containing only two eggs. Read (1998) has reported that 'bumper years' of reproduction can occur, when conditions are exceptionally good compared with typical years. This specimen was collected during 2000, in a year of above average rainfall for the region (Bureau of Meteorology, 2001). This may explain the high clutch size of this individual, and emphasises how variable ('plastic') reproduction in *Ctenotus* may be, and the potential for adjusting reproduction to seasonal conditions.

Testis size trends over seasons were limited by lack of specimens from the period April-September, but we observed a bimodal pattern with peaks for some species in September while others did not reach a maximum until December. James (1991b) found a more uniform pattern of male gonadal cycles. Testis size in *Ctenotus* of central Australia began enlarging in winter, and remained enlarged until January, with a peak in September. Future study of male testicular cycles in mallee *Ctenotus* is needed to reveal whether there are significant interspecific differences in male cycles, or whether our sample merely reflected annual or local environmental fluctuations.

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# BREEDING BEHAVIOUR OF THE POORLY KNOWN AUSTRALIAN HYLID FROG *LITORIA LONGIROSTRIS*

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*Litoria longirostris* Tyler and Davies, 1997 is a little-known Australian hylid frog. The sum total of information about the species consists of descriptions of a preserved type series (Tyler & Davies, 1977) and sperm morphology (Scheltinga *et al.*, 2002) and a short note on field observations of adults and egg masses from streams in the McIlwraith Range, Cape York Peninsula, far north-eastern Queensland (McDonald & Storch, 1993). The latter was important because it confirmed a breeding habit that is unique among Australian hylid frogs (Tyler, 1985). *Litoria longirostris* deposits eggs on dry substrates (e.g. trunks of trees, on granite rocks, under leaves of rainforest shrubs and on palm fronds) typically above still water pools. The strategy is similar to that observed for several hylid species in the Papuan region (*L. iris*, *L. ollauro* and *L. havina*, Menzies, 1993, *L. prora*, Richards, 2002; *L. cf. havina*, Günther, 2006) and in other taxa elsewhere (Duellman & Trueb, 1986). However, the method of amplexus and fertilization remains unknown.

We undertook multiple expeditions to the McIlwraith Range between 2006 and 2008 as part of a research program examining rainforest bird fauna. We observed breeding activity of *L. longirostris* (including calling males, nests, eggs and embryos) on two occasions - first between 20-21 April 2008 and again between 15-17 November 2008. In the later instance, amplexus and egg deposition was directly observed. Here we provide a detailed account of this interaction.

Observations were made along an upper tributary of Peach Creek at approximately 500 m elevation (13°44'S 143°44'E). The site

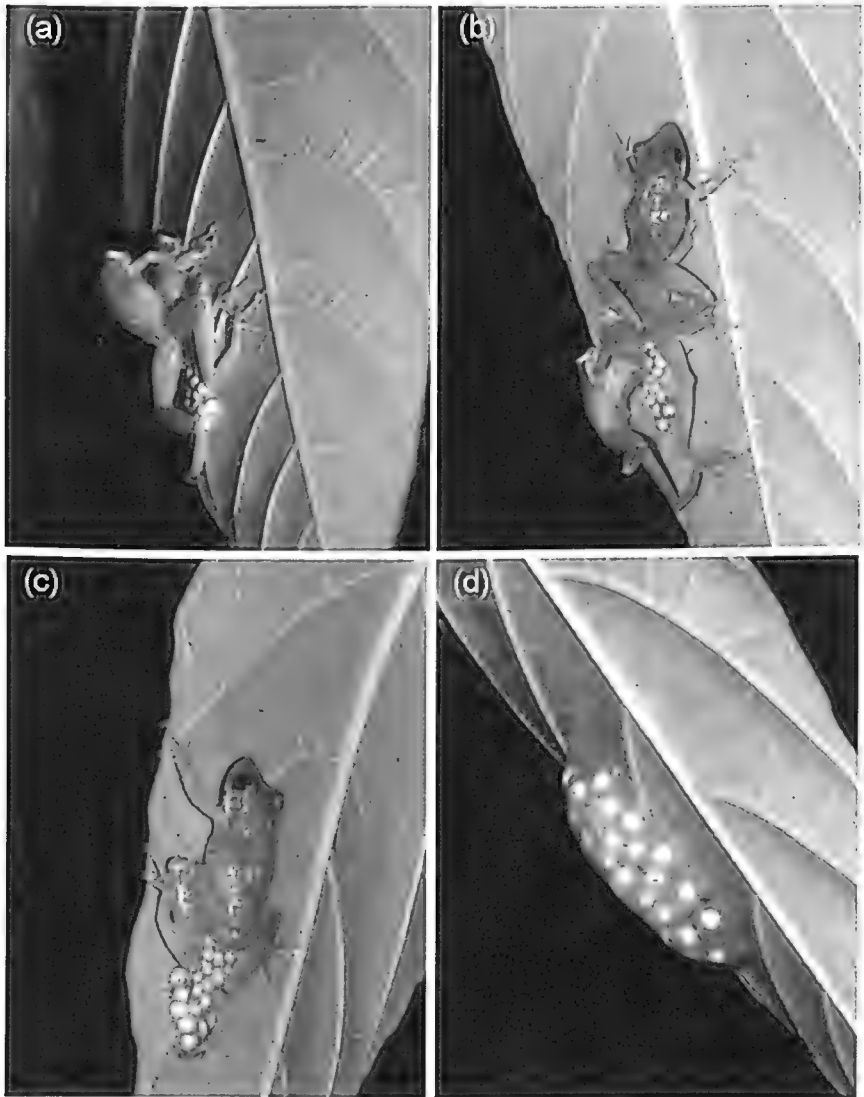
was a shallow meandering, sandy-bottomed stream flowing through rainforest, lined with large Water Gums (*Tristaniopsis exiliflora*), Fan palms (*Licuala ramsayi*) and Alexandra's palms (*Archontophoenix alexandrae*). Numerous roots, fallen timber and occasional bedrock obstructed the channel. Air temperature and relative humidity were approximately 23°C and 90% respectively during the observations with intermittent light rain. Similar conditions had prevailed for at least the previous four days.

At 1940 hrs we found five *L. longirostris* in a clump of stream-side vegetation composed of juvenile palms, *Tristaniopsis* and a 1.3 m sapling of *Ficus* sp. with large lanceolate leaves (~200 x 100 mm). The frogs had been chorusing intermittently since sunset. At first inspection, one pair in amplexus was located on the surface of a *Ficus* leaf overhanging a small, still, stream-side pool formed by a fallen palm trunk. Amplexus was axillary. Three additional males were arranged on nearby leaves within a 50 cm radius. Shortly thereafter, the pair in amplexus moved to the underside of the leaf and faced upwards toward the petiole. The female squirmed forwards for 20-30 mm and, in doing so, rapidly deposited a single layer of pale greenish eggs in a closely packed smear (Figure 1a). Within one minute of the commencement of egg deposition, two other males joined the pair in amplexus. The additional males first mounted behind the attached male, then vigorously pushed at each other using their legs. Eventually one male was dislodged from the leaf altogether and one burrowed beneath the female

(Figure 1b). The female then moved off the egg mass. This left two males straddling the egg mass for a short time, before all three returned to the leaf upper surface.

Within 10 minutes, the female returned to the egg mass, sat straddling it for several minutes and then continued to deposit more eggs (Figure 1c). Two males remained on the

**Figure 1. Breeding interaction of *Litoria longirostris*. Egg deposition by a single pair in amplexus (a) was followed by scramble competition involving multiple males (b). The female moved off the egg mass but later returned to deposit more eggs (c). By the following morning the egg mass had been fully formed into an oblong cluster (d).**



upper surface of the same leaf. Fifteen minutes later, all five individuals were positioned near the egg mass on the upper surface of the leaf and adjacent stem. The egg mass was a single layer of eggs, tightly clustered in an area of about 30 mm by 15 mm. Presumably fertilisation occurred at some point in the initial deposition phase or subsequent struggle phase, though this was not directly observed. Nor is it known if repeat amplexus events accompanied the completion of the egg mass after observations ceased. The following morning at dawn the egg mass had been fully formed into an oblong cluster ~ 30 mm long by 15 mm wide by 10 mm deep, with 30-35 eggs arranged in 2-3 layers at the thickest point (Figure 1d).

A second aggregation of six individual *L. longirostris* (all apparently males - slender and unblotched dorsum, without signs of gravidity) was found 20 m upstream on the same night. Individuals were similarly positioned on vegetation overhanging the water with a single associated egg mass of about 25 eggs adhering to the underside of a leaf. *Rana daemeli* and *Litoria eucnemis* were also recorded in the area, both calling throughout the night.

The above observations represent the first account of amplexus and egg deposition in this species. While these observations were based on only a single breeding interaction, several basic elements of the system seem evident. First, chorusing males typically cluster on substrates over still, stream-side pools (pers. obs.; McDonald & Storch, 1993). Second, axillary amplexus occurs between a single pair at or near the deposition site, followed by deposition directly onto the substrate, where between one and three layers of eggs are deposited while the male straddles the female (pers. obs.). Third, scramble competition between one or more additional attending males can ensue, resulting in struggles for position on the female and/or over the egg mass. Lastly, egg deposition can occur in multiple bouts, with continued attendance by multiple males. However, it is

unclear whether repeated deposition, or indeed clutch-splitting, is a common occurrence. In the instance we observed, the male of competing males may have prompted the female to leave the egg mass after the first layer of eggs was deposited.

Multiple male attendance to laying females and multiple egg-laying bouts described above indicate a role for sperm competition in the mating system of *L. longirostris*. Interestingly, a detailed study of the ultrastructure of spermatozoa in *L. longirostris* has revealed a highly elongated head and tail relative to ten other *Litoria* species examined to date (Scheltinga *et al.*, 2002). These characteristics have previously been interpreted as an adaptation to penetrate the relatively thick gelatinous coat around the eggs (Scheltinga *et al.*, 2002). However, Byrne *et al.* (2003) found that elongation of the spermatozoid, particularly the tail, correlated with an increased risk of sperm competition in the mating systems of myobatrachid frogs. Our observations of the amplexus and egg deposition in this species introduce the possibility that sperm competition may also be an important factor in the evolution of the distinctive sperm morphology of *L. longirostris*. Anecdotal evidence indicates that multiple-male amplexus occurs in at least four Australian species of *Litoria* and that group spawning may indeed be more common than currently realized (Byrne *et al.*, 2002). We add *L. longirostris* to this growing list.

Our observations also extend the documented record of breeding activity for *L. longirostris* to include the months of September, November and April. This suggests a prolonged mating season for the species. Unfortunately nothing is known about environmental constraints on breeding activity or the development period of egg masses and tadpoles. Likewise, the significance of males attending fully-formed egg masses has yet to be determined. Egg masses were observed both during the "Wet Season" (November), as well as "Dry Season" when rainfall and humidity were low (April, September). This suggests that despite terrestrial

deposition of their egg masses, the nesting strategy in this species confers at least some protection from desiccation even when the surrounding forest is relatively dry (pers. obs. and unpublished data). It has been demonstrated that attendant males reduce desiccation mortality through periodic moistening of eggs in several other terrestrial-brooding frog species (e.g.: Taigen *et al.*, 1984; Vockenhuber *et al.*, 2009). Further work will be required to determine if males of *L. longirostris* play a similar role.

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# TIPS FOR SEPARATING *CARLIA ROSTRALIS* FROM *CARLIA LONGIPES* – RESOLVING THE INADEQUACIES OF EXISTING KEYS

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Some *Carlia* species are difficult to distinguish from one another using morphological characters (Couper *et al.*, 2005) and, where similar species occur in sympatry, field identifications can be problematic. An obvious example of this is separating *Carlia rostralis* (De Vis, 1885) from *Carlia longipes* (Macleay, 1877) in north-eastern Queensland. Recent research has shown that '*C. longipes*' is a composite of three allopatric species (Donnellan *et al.*, 2009). The distribution of *C. rostralis* only overlaps with one of these, *C. longipes sensu stricto*. This understanding has enabled the identification of morphological characters, presented herein, that can be used reliably to distinguish *C. rostralis* from *C. longipes*.

## BACKGROUND

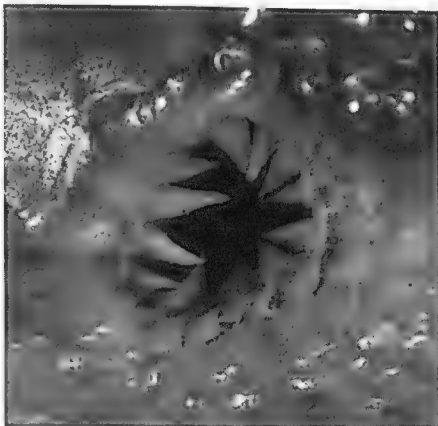
Ingram and Covacevich (1989) in the most recent full revision of Australian *Carlia*, defined *C. longipes* as occurring in northern Australia (Queensland and the Northern Territory), the Torres Strait and southern New Guinea. Perhaps because of the composite nature of their concept of *C. longipes*, these authors produced an ambiguous diagnosis and the couplet in their key separating *C. rostralis* from *C. longipes* used unreliable colour pattern differences. These inadequacies have been perpetuated in the keys of subsequent authors (for example, Cogger, 2000, Wilson, 2005). Donnellan *et al.* (2009) re-examined Australian *C. longipes sensu lato* and divided it into three species; *C. longipes* (found in north-eastern Queensland from the head of Princess Charlotte Bay south to the Gordonvale area), *Carlia sexdentata* (Macleay, 1877) (from the tip of Cape York Peninsula south to Princess Charlotte Bay, north-east Arnhem Land and adjacent islands and the islands of Torres Strait) and *Carlia quinquecarinata*

(Macleay, 1877) (Darnley Island in western Torres Strait but may also occur on nearby Murray Island and in southern Papua New Guinea; see Donnellan *et al.*, 2009). A broad species concept for *C. longipes* masked distinct ear lobe differences between *C. longipes sensu stricto* and *C. rostralis*.

## EAR LOBULE DIFFERENCES

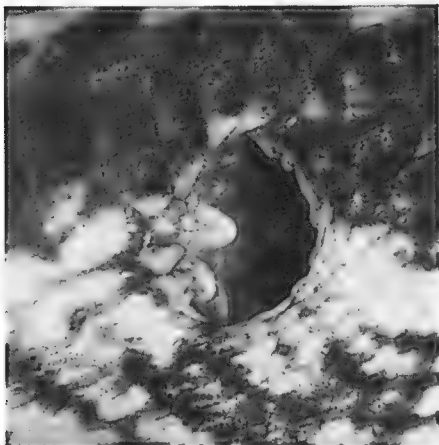
In *C. longipes*, the ear aperture is completely surrounded, by enlarged, pointed lobules which may be acute or broadly triangular (Figure 1) whereas there are only a few enlarged lobules on the anterior surface of the ear aperture in *C. rostralis* (Figure 2). The condition for *C. rostralis* is not unlike that seen in some specimens of *C. sexdentata*, but as these species have non-overlapping distributions, this does not present a problem for field identifications. Further, although *C. rostralis* and *C. sexdentata* can have a similar ear state, the normal conditions for both

**Figure 1. *Carlia longipes* – ear aperture completely surrounded by acute or broadly triangular lobules. Anterior to the left.**





**Figure 2. *Carlia rostralis* – ear aperture with two enlarged, bluntly tipped lobules on anterior edge, other surfaces free of lobules. Anterior to the left.**

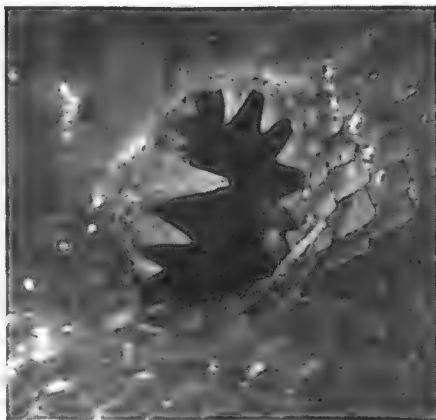


species are quite different. *Carlia rostralis* typically has two enlarged, bluntly tipped lobules on the mid anterior margin of the ear aperture – the upper lobule being the largest (Figure 2) while a distinct 'comb' of lobules is usually present on the anterior surface of the ear aperture in *C. sexdentata* and some smaller pointed lobules are also present across the dorsal and upper posterior margin of the ear aperture (unlike the condition in *C. longipes*, *C. sexdentata* does not have enlarged lobules completely surrounding the ear aperture; Figure 3).

### PATTERN DIFFERENCES

The key presented by Ingram and Covacevich (1989) gives both male and female pattern descriptions for *C. rostralis* yet only provides a broad pattern description for *C. longipes* that encompasses both sexes. The key suggests that the black upper lateral zone extends to the hindlimb in *C. rostralis* but only to the forelimb in *C. longipes sensu lato*. While there may be a tendency towards this condition, many *C. longipes* and *C. sexdentata* individuals, particularly females and juveniles, have

**Figure 3. *Carlia sexdentata* – ear aperture with several enlarged lobules on anterior edge and additional small, sharp lobules on dorsal and upper posterior margins. Anterior to the left.**



the dark upper lateral zone extending well beyond the forelimb. In their key, Ingram and Covacevich (1989) mention the presence of a pale dorsolateral stripe in female *C. rostralis* but make no mention of this condition for female *C. longipes* in the apposing character state. These authors clearly did not regard the presence or absence of a pale dorsolateral stripe in females as diagnostic as its presence is discussed in the accompanying species accounts for both taxa. In actuality, the stripe is indistinct in female *C. longipes* vs. well defined in female *C. rostralis*. This omission from the key has caused subsequent authors (for example, Cogger, 2000) to infer that female *C. longipes sensu lato* lack a pale dorsolateral stripe, resulting in ongoing difficulty separating the two species. It also highlights the importance of using keys in conjunction with more detailed species accounts (Shea, 1995).

There is no difficulty in distinguishing males in breeding condition. Breeding male *C. rostralis* typically have black throats, bright red flanks (bordered above by a broad, black upper lateral stripe) and heavily speckled dorsal surfaces. In *C. longipes sensu stricto*

the throat is pale, the red flanks are not bordered above by a black upper lateral stripe and the dorsum is uniform or only slightly speckled.

Other pattern characteristics that are useful in separating these taxa and are particularly useful for females and non-reproductive males are:

1. In *C. rostralis*, the black upper lateral stripe encloses the upper portion of the ear aperture giving it a distinctive very dark upper margin (Figure 2). In *C. longipes*, the black upper lateral stripe does not enclose the upper portion of the ear aperture. Instead, the pale midlateral stripe diverts above the ear giving it a pale upper margin (Figure 1).

2. In *C. rostralis*, the pale dorsolateral stripe is usually conspicuously edged above with black, between the ear and forelimb. In *C. longipes*, there is no, or only a slight, black edging.

The insertion of the following two couplets into existing keys will substantially reduce confusion between these species in the field and also distinguish both from the allopatric *C. sexdentata*:

**A.** Ear aperture completely surrounded by acute or broadly triangular lobules = ***longipes***  
Not as above, **see B**

**B.** Ear aperture with two enlarged, bluntly tipped lobules on anterior edge, other surfaces free of lobules (south of 14°30'S) = ***rostralis***.

Ear aperture with several enlarged lobules on anterior edge and additional small, sharp lobules on dorsal and upper posterior margins (north of 14°30'S) = ***sexdentata***

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# MALE COMBAT IN THE MULGA SNAKES *PSEUDECHIS AUSTRALIS* (SERPENTES: ELAPIDAE): A SERIES OF OBSERVATIONS FROM NORTHERN AUSTRALIA

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## INTRODUCTION

Within the genus *Pseudechis*, male combat has been observed in *P. australis* (Shine, 1987b), *P. colletti* (Mirtschin & Davis, 1992), *P. guttata* (Williams, 1992) and *P. porphyriacus* (Shine *et al.*, 1981). These observations confirm the occurrence of this behaviour in the genus, but its purpose remains unknown. However, in the absence of specific studies, the function of male combat may be illuminated by carefully documenting episodes.

Observations of male combat in *P. australis* are very briefly presented by Shine (1987b). However recent molecular work has shown *P. australis* may be a composite of cryptic species (Kuch *et al.*, 2005); these are currently being studied and formally described (D. Trembath, pers. obs.). The observations by Shine (1987b) precede this knowledge so it is unclear which taxa were involved. In this note we present four detailed observations complete with photographs of male combat in what we believe is the nominotypic form of *Pseudechis australis* from Northern Australia.

## OBSERVATIONS

Three separate incidents of *P. australis* combat were observed between 2 – 11 September 2008 at Mornington Wildlife Sanctuary in the Central Kimberley region of Western Australia (17°30'S 126°06'E).

The first observation occurred from 1740 hrs on the 2 September 2008, and involved two large male *P. australis* of similar size (B581: snout-vent length 1440 mm, total length

1694 mm, mass 1370 g; 9A30: snout-vent length 1551 mm, total length 1757 mm, mass 1235 g). The snakes were initially observed coiled around one another, 'wrestling' out in the open next to a large reed bed (Figure 1a) and continued wrestling for a further 40 minutes (Figure 2). During this period, the intensity and behaviour changed in a predictable pattern: the snakes would move parallel along the ground, pushing at each other. This would be followed by gentle coiling around one another, merging into an intense, intertwined coil (Figure 2). This behaviour sequence was repeated many times. Throughout, they would often raise as much as the first third of their heads and fore bodies off the ground, trying to get higher than the other, pushing side to side and up and down in an attempt to push their opponent's head to the ground (Figures 1a-b, 2). Both snakes constantly hissed, flattened their necks and occasionally expanded their throats (Figure 2). At one stage one individual attempted to bite the other, though no contact was made. Once the bout ceased, the apparent 'loser' (B581) moved away from the area. The 'winner' (9A30) moved slowly into the reed bed, lying among the reeds where he remained stationary for a further 30 minutes.

The second observation occurred on 4 September 2008, and involved the same two snakes (they had been micro-chipped) at the same location. This interaction appeared much more aggressive, with the snakes becoming more tightly entwined, hissing more, and making much more erratic move-

ments. The snakes also covered more ground during this bout; at one stage they moved into the reed bed, climbing up the reeds almost one metre off the ground as they wrestled (Figure 3a). The wrestling continued as they then moved well away from the reed bed area and out onto an access road, up to 20 metres from where the bout was first observed. This bout, when observed, lasted for 25 minutes, upon completion both snakes uncoiled and moved away. In contrast to the first fight, this time 9A30 left the area, while B581 remained at the site of combat, later retreating down a large burrow under a tree stump about 50 m away.

A third observation was made from 1530 hrs on 11 September 2008 by a visitor to the sanctuary. Two *P. australis*, presumed different individuals from the previous observations, were observed in a combat bout almost two kilometres from the previous combat location. The snakes' behaviour was similar to the above observation, displaying tight coiling, hissing, raising their fore bodies high above the ground and attempting to pin the others' head down.

In addition to these observations one of us (DT) received a photograph of two large *P. australis* engaged in combat (Figure 3b). Unfortunately the exact locality was not noted by the observers as they were travelling on the Old Telegraph Track south of the Jardine River, Cape York Peninsula, north Queensland. They did however relay that they observed the snakes in August 2005 and they were about "a metre and a half" long, and were not disturbed by the photographs and/or car.

## DISCUSSION

Male combat has been observed to date in the following Australian elapid genera: *Austrelaps* (Shine & Allen, 1980; Lintermans, 1992; Clemann & Saddler 2000; Jenner, 2004), *Cryptophis* (Shine, 1984), *Demansia* (Shine, 1980; Covacevich, 1994), *Elapognathus* (Shine, 1994), *Hemiaspis* (Shine, 1987a), *Notechis* (Firmage & Shine, 1996;

Fearn & Staubmann, 2001), *Oxyuranus* (Hosmer, 1953; Worrell, 1964; McRae & Covacevich, 1997), *Parasuta* (Turner, 1992), and *Pseudonaja* (Fleay, 1943; Shine, 1989; Shine, 1991; Fyfe, 1993; Maryan, 2004; Trembath et al., 2006).

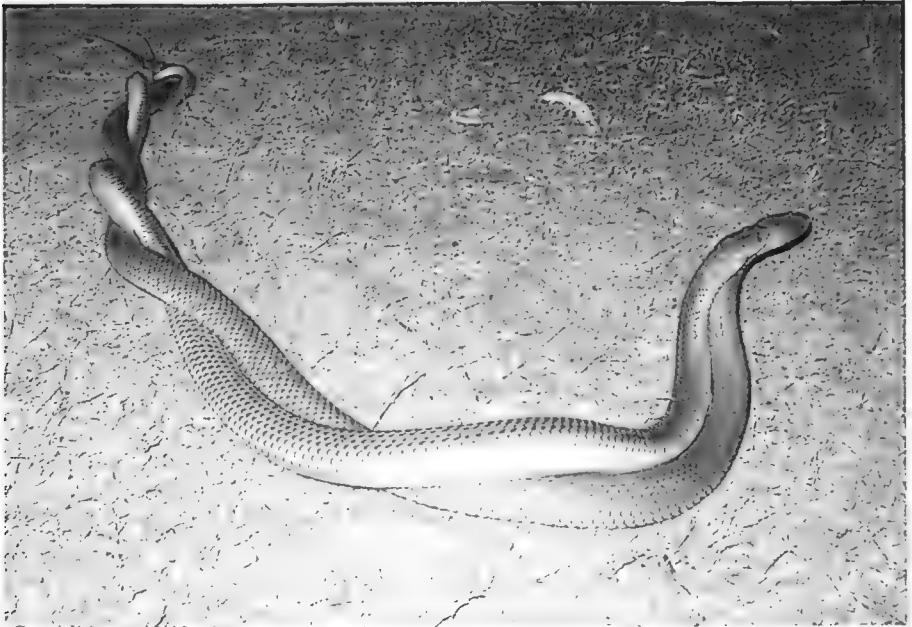
Combat in snakes is often attributed to intra-sexual competition for mates or breeding territories, or as an intersexual display (Shaw, 1951; Akester, 1979; ), as most bouts are observed during the breeding season. However, Shaw (1951) also suggests that fights may occur when competing for food or defending of homosexual courtship.

The combat observations reported here (the Kimberley observations, and broadly speaking, the Cape York observation) are similar to those described for other *Pseudechis* species, and indeed with other elapids. This suggests that the behavioural elements of male combat may be primitive for the genus.

The breeding season for Kimberley *P. australis* is likely to be the same as other populations (September-October), as gravid females have been found across the whole of Australia during November (Shine, 1987b). Additionally one captive breeding study confirms this with ovoposition occurring nine weeks after mating (Fitzgerald & Pollitt, 1981). Given that most documented observations of male combat in *Pseudechis* occur during the likely breeding season, it seems unlikely that the competition is over food, and rather that it is either an intersexual display or intrasexual competition. In order to assess whether the fights were an intersexual display, we searched the area around the fighting snakes intensively. However, we failed to find any females near the fighting males.

The repeated observations of the same snakes at the same location suggest that both these individuals may have been competing over a home range or activity area, or retreat site(s). There is little information on home range and territory in large elapid snakes, though males within *Pseudechis* and *Pseudonaja* appear to have relatively large home

Figure 1. (a & b). Male *Pseudechis australis* engaged in combat at Mornington Wildlife Sanctuary, Western Australia. Both pictures depict the snakes attempting to push each other's heads to the ground.



**Figure 2. Male *Pseudechis australis* exhibiting throat puffing, neck flattening, raising their fore-bodies and tight coiling during a combat bout at Mornington Wildlife Sanctuary, Western Australia.**

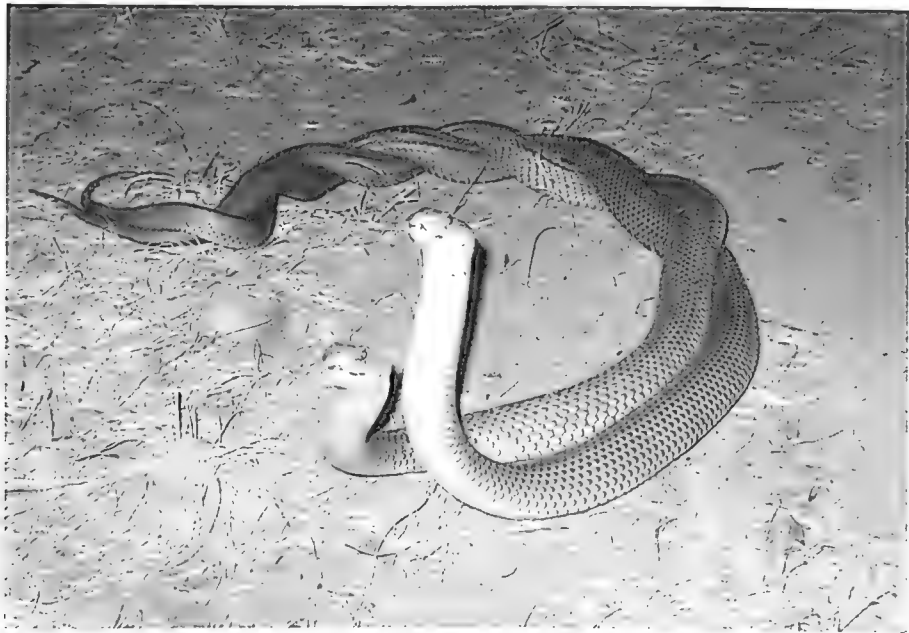


Figure 3. (a) Male *Pseudechis australis* involved in a combat bout in thick vegetation at Mornington Wildlife Sanctuary, Western Australia; (b) presumed male *Pseudechis australis* engaged in combat on Old Telegraph Track, south of Jardine River, Cape York Peninsula in August 2005.





ranges or activity areas and move about readily (Shine, 1979, 1987c; Whitaker & Shine, 2003), particularly during the breeding season (Shine, 1987c). Large female elapids have smaller ranges and are less mobile (Shine, 1979). During the breeding season, males may attempt to exclude potential competitors from the home ranges of large females.

In many other records of male-male combat in large elapid species, combat generally occurs between snakes of similar size and in large, mature individuals (see Shine *et al.*, 1981; Fearn & Staubmann, 2001; Trembath *et al.*, 2006). Combat is rarely reported for smaller, subordinate males. In the observations reported here, a smaller male *P. australis* (904C: 1224 mm snout vent length, total length 1419 mm, mass 752 g) was captured two days later in the vicinity of the two larger snakes, but was not seen in a combat battle. Smaller individuals may not be perceived as a threat or competition to the large individuals in the same area.

Combat has only been documented for a handful of Australian species. However it is likely to be under-reported because of the cryptic nature of elapids, particularly when breeding. Further detailed observations and focal studies on the role of male combat may help to explain this behaviour.

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## PITCHER THIS!

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In October 2005, at a site NW of Albany, Western Australia, a frog was observed climbing in and out of the pitchers of the carnivorous plant *Cephalotus follicularis* Labill. (Figure 1). To my knowledge, movement between pitchers has not been reported before for frogs with *C. follicularis*.

The Albany pitcher plant, *C. follicularis*, is endemic to south-western Western Australia and grows in damp peaty sands in a patchy distribution between Augusta and Wangerup. It is the only genus and species in the Cephalotaceae, not related to other pitcher plants such as those in the Nepenthaceae and Sarracenaceae. In the wild it has a vulnerable conservation status (IUCN 2.3), predominantly due to illegal collection and habitat loss. The Albany pitcher plant is a small herbaceous plant. Normal leaves are produced in rosettes and flowers appear in summer on long stalks to 20–60 cm high (Clarke, 1988). Modified leaves form pitchers to 2.5 cm in length with a lid that partially covers the pitcher, sheltering the digestive enzymatic liquid inside from rain and the lids wilt to cover the pitcher reducing evaporation when conditions are dry (Parkes & Hallam, 1984).

The frog observed climbing out of the *C. follicularis* pitcher was a juvenile and therefore difficult to identify. It may be *Geocrinia*, possibly a juvenile *Geocrinia leai* (pers. comms., Dale Roberts and Marion Anstis). This species occurs in vegetation in swamps and near streams, similar habitats to the Albany pitcher plant. The frog lays its eggs on plant material above the water surface and the tadpoles fall into the water after hatching (Barker *et al.*, 1995).

Prey is attracted to *C. follicularis* by nectar exuded from specialised glands around the lid and opening and by the attractive coloura-

tion of the pitchers, particularly in the UV spectrum (Parkes & Hallam, 1984; Joel *et al.*, 1985). The sides and lips of the pitchers have multiple adaptations to prevent the escape of animals that find their way inside. These include including modification of microtopography that reduce the adhesion of insect foot pads, disorienting light 'windows' on the lid, downward pointing hooks along the rim and a curved cornice inside the pitcher (Arber, 1941; Parkes & Hallam, 1984). Two types of digestive glands occur inside the pitchers (Parkes & Hallam, 1984) that produce phosphatases (Plachno *et al.*, 2006). The majority of prey drown before being digested rather than being killed by the solution, but frogs, with permeable skin, may be more susceptible. The frog observed in the *C. follicularis* plants appeared to avoid adaptations to prevent prey escape and seemed unaffected by the digestive fluid.

The most common prey of *C. follicularis* include Diptera, Coleoptera, Formicidae and Arachnida and up to 30% of total plant nitrogen can be attributed to carnivory (Schultz *et al.*, 1997), which is low for carnivorous plants. However more than 150 other species also live inside the pitchers including Protozoa, Oligochaeta, Nematoda, Arthropoda, Rotifera, Tardigrada and others (including bacteria, algae and fungi) (Clarke, 1985, in Yeates, 1992). The identity and dependence on *C. follicularis* of the majority of these species is unknown, but the larvae of the stilt fly *Badisis ambulans* is an obligate commensal (Yeates, 1992). It is possible that a frog could feed on these species inside the pitcher of *C. follicularis* plants.

Pitcher plants from the unrelated Nepenthaceae can feed on the faecal material of diverse phytotelmata fauna rather competing with them for food, taking advantage

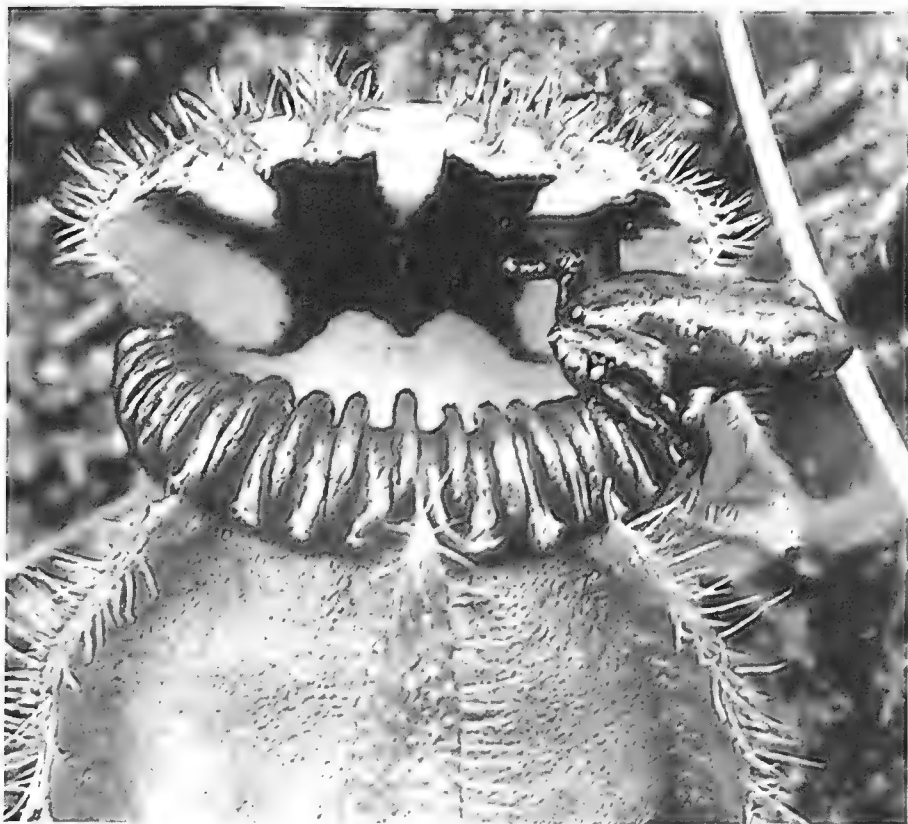
of the digestive systems of the fauna (Mogi & Yong, 1992; Cresswell, 1998). Some *Nepenthes* species from Borneo are adapted to capture the faeces of shrews and may have very little reliance on trapped invertebrates (Clarke *et al.*, 2009).

There are few examples of frogs living in pitcher plants. The tadpoles of the Asian sticky frog (*Kalophrynus pleurostigma*) develop in the pitchers of *Nepenthes ampullaria*, but do not feed, apparently surviving on their yolk sacs (Lim & Ng, 1991). Other frogs, such as the American green tree frog (*Hyla cinerea*), wait on the lip of North American pitchers and catch prey attracted by the plants (Wray

& Brimley, 1943), but in turn probably provide the plant with faecal material (D'Amato, 1998). Some pitcher plants are capable of digesting frogs (Schnell, 2002).

There is one other record of a frog (species unknown) found inside a *C. follicularis* pitcher (Shulze *et al.*; 1997) suggesting the frog-pitcher interactions I observed may not be a unique occurrence. It is possible that a frog, perhaps *G. leai*, completes some of its lifecycle in the Albany pitcher plant, takes food from the phytotelmata and provides faecal material to the plant, or just visits the water body.

**Figure 1. A juvenile frog, possibly *Geocrinia leai*, perched on the edge of a *Cephalotus follicularis* pitcher NW of Albany, October 2005. The pitcher was about 2.5 cm high.**



## ACKNOWLEDGMENTS

Gratitude is extended to Martyn Robinson for facilitating the frog identification, Dale Roberts and Marion Anstis for their tentative identification of the frog and Brian Cooke for locating the *C. follicularis* population.

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# INDIVIDUAL MARKINGS ARE A RELIABLE NON-INVASIVE MEANS OF IDENTIFICATION OVER TIME IN BLOTCHED BLUE-TONGUED LIZARDS, *TILIQUA NIGROLUTEA*

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## INTRODUCTION

Pattern is often used by zoologists who wish to uniquely identify an individual animal within a population. For pattern to prove a reliable method of identification, it must be both unique and constant through time, as has been demonstrated in species such as badgers (Dixon, 2003), polar bears (Anderson & Waterman, 2007) and grey nurse sharks (Bansemer & Bennett, 2008). However, few studies have assessed the constancy of pattern elements in reptiles, which are often identified instead by implanting PIT tags (Jemison *et al.*, 1995; Hilterman *et al.*, 2007) or by toe-clipping (Sacchi *et al.*, 2007). For some studies, pattern may be a less intrusive and more potentially reliable method of distinguishing individuals.

There is currently no information available on pattern stability in the blotched blue-tongued lizard (*Tiliqua nigrolutea*). Markings displayed by blotched blue-tongue lizards are a combination of pale blotches and bands on a black background, and differences in these patterns between individuals are immediately distinguishable. However, it is not enough simply to state that these patterns appear unchanged over time, they must be quantified and scored in some way to confirm that this is so. This project has investigated whether pattern remains sufficiently constant over time to be used as a reliable method of individual identification in *T. nigrolutea*.

## METHODS

We took sequential digital photographs of the dorsal surface of a total of 29 blotched blue-tongue lizards (representing five litters) at three ages: 12 months, 18 months and four

years, by which time the lizards had reached adult body size (SVL > 24cm in males; SVL > 26 cm in females).

We created a key of ten characters (see Table 1), each with multiple character states, focusing on features such as the colour shades of the paler regions (e.g. grey/gold/salmon), the arrangement of individual blotches into connected bands and particular regions of the body such as neck (Figure 1) and pelvis (Figure 2) (dorsal pattern only). The photographs were scored for these character states by a single operator (CG). Not all photos displayed all ten characters clearly, so only characters that were visible in the photos were scored. Only characters where a score was available for at least two of the three sample periods dates were considered. The proportion of characters scored for which each individual achieved an identical character state over time was calculated as a percentage for each individual in a litter (e.g. 7 out of 8 characters scored  $\times 100 = 87.5\%$ ), and these were used to calculate litter means. All characters were scored with knowledge of the identity of the animal, but no knowledge of its previous character scores.

## RESULTS AND DISCUSSION

Two of the ten characters (6 and 7, relating to tail pattern) were not sufficiently clearly visible in all photos and so were not scored. Of the remaining eight characters, variation over time, resulting in individuals being scored differently, occurred in a total of five out of 29 individuals only. No individual varied on more than a single character and all animals were judged on a minimum of seven characters (determined by image quality).

**Table 1. Characters and character states used to assess changes in pattern over time in *Tiliqua nigrolutea*.**

Character	Character states
1. Neck bar proportions	A. One bar extends further B. Bars same length
2. Length of neck bars	A. Both extending not more than 2 cm posterior to front leg B. One or both extending several cm or more posterior to front legs
3. Neck bar breaks	A. Break on one side only B. Break on both sides C. No breaks
4. Inner edges of neck bars	A. very smooth on both sides B. Multiple parallel indents C. Other irregularities
5. Single blotch at posterior of head	A. Disconnected from neck bars B. Connected to both neck bars C. Connected to only one neck bar
6. Tail bands	A. All bands extend across tail B. All bands extend part way across tail C. Combination of full and half bands
7. Broken tail bands	A. Bands directly opposite each other B. Bands offset C. Not applicable
8. Longitudinal bars on dorsal pelvis	A. Parallel bars B. Combination of blotches and a bar C. All blotches, no bars
9. Colour of pale blotches	A. Consistent "standard" colour across whole dorsal surface (typical olive/yellow) B. Darker than "standard" colour (brown/salmon) across whole dorsal surface C. Bright orange patches or tinges present in some places D. Paler than "standard" colour (yellow/green/silver) across whole dorsal surface E. Golden patches across whole dorsal surface
10. Nature of overall blotching pattern	A. Blotches not lined up to form bands B. Blotches lined up to form bands; bands can be offset



Figure 1. Characters 1-5 in the pattern key distinguished individual *Tiliqua nigrolutea* pattern on the basis of overall dorsal surface markings in the area of the neck. Shown here is an irregular inner border on two neck bars which extend approximately equal distances posterior to the front legs.

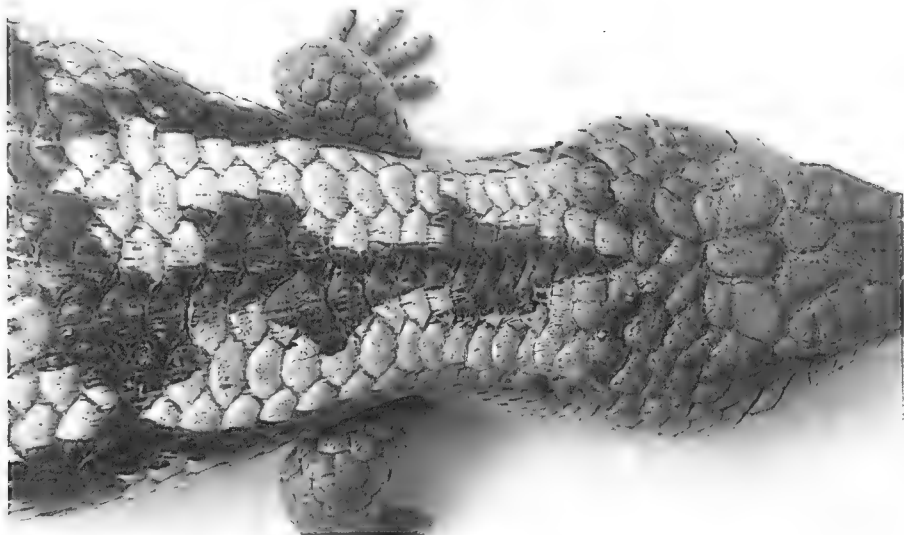
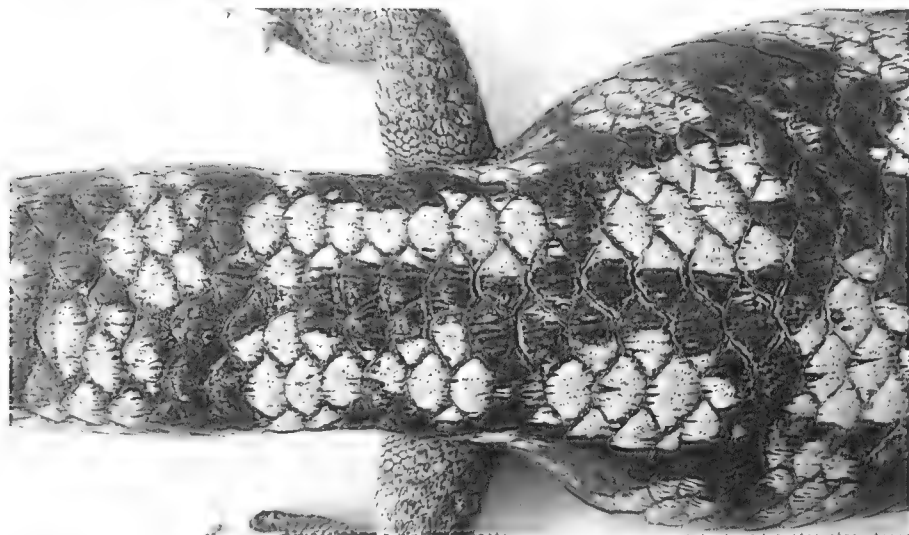


Figure 2. Character 8 in the pattern key distinguished individual *Tiliqua nigrolutea* pattern on the basis of dorsal markings on the pelvis. Shown here is a single extended bar on the left, opposite two separate blotches on the right



**Table 2. Mean pattern similarity over time for each of five litters of *Tiliqua nigrolutea*.**

Litter number	Mean litter character similarity (%)
1	96
2	88
3	93
4	93
5	95

Table 2 shows mean percentage pattern similarity for each litter (combining colour and pattern characters). Mean similarity over time for all 29 individuals was 93%, slightly lower than expected. For characters relating to pattern structure (Characters 1-5, 8, 10), only one individual was scored differently on a single character (4). The remaining changes, in four individuals, were due to alteration of colour hues (Character 9), suggesting that colour is not as reliable an identifier as pattern structure. Such colour changes have been observed to occur commonly during the life of individuals of *T. nigrolutea*, as a result of fighting, moulting, or physical injury, and did not change the shape of the markings (A. Edwards pers. obs.).

These results demonstrate that, as suggested by the Australian Society of Herpetologists (ASH Inc., Position Paper No. 1), pattern in *Tiliqua* species is highly stable over time, and therefore provides a reliable, non-invasive means for identification of individuals. With a photograph, either in black and white or colour, it should always be possible to recognise an individual, even if it has not been encountered in the wild for a period of years. In fact, in the captive colony on which this study was done, there are individuals which have been identifiable by their unchanging pattern structure for more than 15 years to date.

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# COLOUR-PATTERN POLYMORPHISM IN LIZARDS OF THE GENUS *PRASINOAEMA* (SQUAMATA: SCINCIDAE)

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The scincid genus *Prasinohaema* contains five named species and is restricted to New Guinea, adjacent islands along its southeastern peninsula, and the Solomon Islands (Greer, 1974; Mys, 1988). The most notable feature of this genus is that its members have green blood plasma, a feature caused by high concentrations of biliverdin (Austin & Jessing, 1994) and not found in other amniotes. This imparts a greenish or bluish cast to some internal tissues (Greer & Raizes, 1969). Also noteworthy are that members of the genus have prehensile tails with modified scales at the tip and that they are ovoviviparous (Greer, 1974). Relationships of *Prasinohaema* to other scincids remain uncertain (Allison & Greer, 1986), and no attempt has yet been made to resolve relationships within the genus. Biological information on these species is sparse, barely extending beyond original diagnoses and geographic range data; however, a survey of blood parasites in four of the species from five localities showed infection rates to be very low (Austin & Perkins, 2006).

In addition to their unique blood colour, some species of *Prasinohaema* demonstrate interesting polymorphisms in their colour patterns. Greer and Raizes (1969) mentioned that male *P. prehensicauda* (treated under the name *Scincella prehensicauda*) were predominantly green whereas females were brown with darker crossbands. Further, they noted that *P. flavipes* (treated under the name *Spheonomorphus flavipes*) occurred in three pattern morphs: unicolour brown, brown with darker crossbands, and striped. Woodruff (1972) also mentioned the colour-pattern polymorphism in *P. prehensicauda*, noted that the green colouration of males faded to golden brown in preservative, and provided a black-and-white photograph of preserved speci-

mens of both sexes. The polymorphisms of both species (originally described under the genus *Lygosoma*) initially went unnoticed because type series for both were small, consisting of only two male *P. prehensicauda* ( Loveridge, 1945) and a single female *P. flavipes* (Parker, 1936).

Despite the suggestive brief remarks made by Greer and Raizes (1969) and Woodruff (1972), neither detailed descriptions nor colour photographs of these colour-pattern variants have been provided. This is unfortunate because colour-pattern polymorphisms of the magnitude seen in these two species are not common among scleroglossan lizards. I recently obtained series of both species from the vicinity of Kunida, Muller Range of Southern Highlands Province, Papua New Guinea, that allow for a more detailed assessment of colour-pattern variation in both species. These specimens are deposited at the Bernice P. Bishop Museum (BPBM) in Honolulu, Hawaii. I take this opportunity to provide colour illustrations and more detailed descriptions of each so as to stimulate greater awareness of the interesting biology of these lizards.

## COLORATION

### *Prasinohaema flavipes*

**Unicolour morph.** The dorsum and sides are brown with each scale posteriorly margined in darker brown; in life, the sides may have a greenish-yellow cast (Figure 1A) or not (Figure 1B). Animals frequently have a few scattered dark-brown dashes (Figure 1B), most commonly on the sides, which can vary from sparsely to heavily streaked. When dark dashes are present they are sparse mid-dorsally. The venter may be lemon yellow or greenish-yellow in life (Figure 1C) and is dirty

white in preservative; it may be flecked with dark brown laterally, but only in those specimens that are streaked laterally. A short dark-brown dash is present before and after the eye (Figure 1B). Ground colour of the limbs is like the dorsum, and the limbs lack dark dashes but have some vague, paler brown spotting (Figure 1A, B).

**Banded morph.** Generally similar to the unicolour morph but with many dark-brown dashes that are denser, larger, and more-or-less arrayed in a pattern to comprise irregular crossbands (Figure 1D). These bands are typically broken and irregular and vary from 1 - 3 scales in depth. The dark postocular stripe is larger and better developed than in the unicolour morph and is followed by two or three large dark-brown blotches to the point above the forearm insertion (Figure 1D). These postocular blotches are least developed in the two specimens with the most weakly developed dorsal banding. Dark-brown flecks are also present on the limbs, which impart to the limbs a more spotted appearance than seen in the unicolour morph. The venter is greenish-yellow in life, usually with dark-brown dashes, at least laterally (Figure 1E); it is dirty white in preservative. Three of 12 individuals are heavily covered with these dashes, but most have them confined to the lateral margins of the venter.

**Striped morph:** The central 7-8 scale rows of the dorsum comprise a field of dark brown with a peppering of small tan dashes that vary from moderate to heavy in concentration (Figure 1F). This dark field is subtended by a tan dorsolateral stripe 2 - 3 scale rows in width. Below this, the ground colour is the same tan or light-brown colour (with a yellower cast ventrally) but is heavily streaked with dark-brown or black dashes of varying length, which impart to the sides a generally darker-brown appearance. White spots are scattered within this lateral field (Figure 1F). The dark postocular bar and blotches seen in the banded morph are usually merged into a single wide, irregular stripe that is more-or-

less continuous with the dark lateral field, but these blotches remain distinct in a few animals. In life, the venter is greenish-yellow with scattered brown dashes, but these are sparser than in the banded morph; the venter is white in preservative. The limbs are spotted with both lighter and darker brown scales, as in the banded morph.

The palms and soles of animals of all three colour morphs are yellow, which can vary from bright to dark. The mouth lining has a pale-blue cast, and the tongue is blue-black. The peritoneum of all specimens is dark black dorsally and laterally; ventrally it is also black but not uniformly distributed, which makes the ventral peritoneum appear unevenly blotched. There is no white colour in the peritoneum.

In the sample of 38 specimens obtained by me, 21 are of the unicolour morph, 12 of the banded morph, and five of the striped morph. The total sample of animals, collected from 23 March to 4 April, 2009, consisted of seven immature females, 11 mature females, three immature males, and 16 mature males. Hence, the sex ratio did not differ meaningfully from 1:1. Nor did it do so within colour morphs: there are 11 males vs. 10 females of the unicolour morph, five males vs. seven females of the banded morph, and three males vs. two females of the striped morph. Only two of the mature females contained developing embryos; the remainder contained yolking follicles and expanded, convoluted oviducts. The two gravid females (both of the unicolour morph) each contained four embryos. In the first female, two embryos were unicolour and two were banded. In the second, one embryo was unicolour, two were banded, and one was striped. Hence, all colour morphs can be produced in the same litter.

### ***Prasinohaema prehensicauda***

**Females:** The dorsum is medium brown, flecked with tan, and with narrow dark-brown crossbands on body and tail; these crossbands can vary in number from approximate-

**Figure 1. Colour-pattern variation in *Prasinohaema flavipes*. Dorsal views of unicolour morph, BPBM 34219 (A) and BPBM 34235 (B); banded morph, BPBM 34234 (D); and striped morph, BPBM 34238 (F); and ventral views of unicolour morph, BPBM 34216 (C) and banded morph, BPBM 34234 (E).**

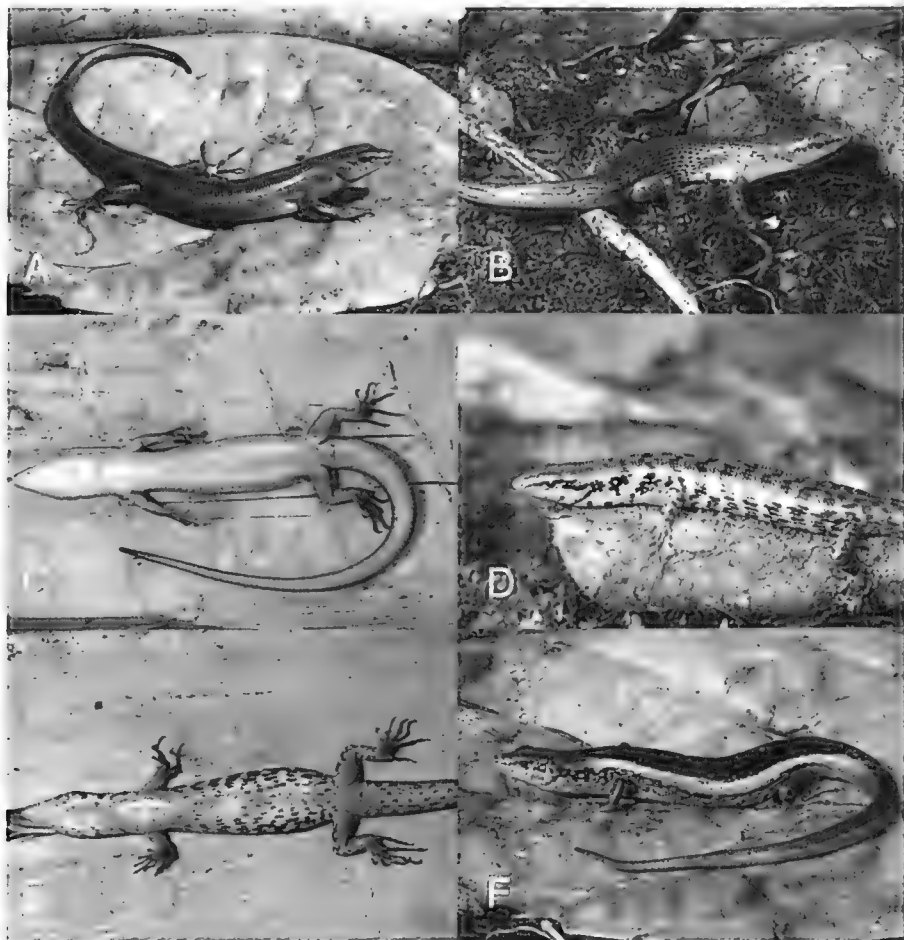


Figure 2. Sexual dimorphism in *Prasinohaema prehensicauda*. Females BPBM 34249 (A) and BPBM 34255 (B), and male BPBM 34621 (C), showing blue colouration of mouth and tongue of latter (D).



ly 6 - 9 on the body and vary slightly in the degree to which they contrast with the ground colour (Figure 2A, B). In one specimen (BPBM 34256), the dark crossbands are not well differentiated from the ground colour. Greenish-yellow flecks and blotches are densely scattered throughout the dorsum, sides, face, and tail (Figure 2A) or may be limited to the more anterior regions (Figure 2B). The scales encircling the eye are white. The dark crossbands turn to black on the lower flanks. The brown ground colour changes to golden brown in preservative, and the green-yellow flecks become white. The central 7 - 8 scale rows of the venter are white, and these scales are outlined in brown either throughout the venter or only posteriorly. The chin and throat have many dark-brown or black blotches and flecks, as does the ventral side of the tail. This dark ventral flecking is better developed in a mature female specimen than in the two immature ones. The tops of the hands, feet, and digits are brown.

**Males:** The central 6 - 9 dorsal scale rows are brown (golden brown in preservative), the sides are lime green (Figure 2C) or pale green and are heavily blotched with lemon yellow (Figure 2C) or pale yellow; the scales encircling the eye are lemon yellow (Figure 2C, D). In preservative, the green on the sides becomes pale straw yellow and the yellow blotches fade to white. The brown dorsal stripe contains white flecks in two of five mature males; these flecks were yellow in life. The chin and throat are white with a few tiny brown or black punctations; the central 6 - 9 scale rows of the venter are white, and the scales under the tail are outlined in brown. The tops of the hands and feet are green, whereas the tops of the digits are brown.

**Immature male:** A single immature male is intermediate in colour pattern between adult males and females. In preservative, it has the mid-dorsal brown ground colour largely limited to the central ten scale rows on the anterior body, but this colour extends ventrally down the sides at midbody and posterior to that. Hence, the sides are yellow anteriorly

(presumably green in life) but darker brown after midbody. There are mid-dorsal crossbands extending down the sides posterior to midbody. The sides and dorsum are heavily blotched with white (presumably green-yellow in life). The head is darker golden brown, and the face has some dark-brown blotches. The venter is white, the sides of the chin and throat have dark-brown blotches, and the lower sides of the body and tail also have black blotches. The lips are dusted with dark gray.

The palms and soles of both sexes are bright yellow or orange. The mouth lining is bright blue or greenish-blue (Figure 2D); the tongue may be the same colour or may be blue-gray. The peritoneum of all specimens is dark black dorsally and laterally and is white mid-ventrally, often with black blotches.

In my sample of nine specimens obtained from 17–31 March, 2009, one is a mature female, two are immature females, five are mature males, and one an immature male. The colour pattern of the immature male indicates an ontogenetic change from the brown, crossbanded female pattern to the green-and-yellow pattern of adult males.

## DISCUSSION

Colour-pattern polymorphism in lizards appears to be of uneven phylogenetic distribution, but I have found no general treatment of the topic. Sexual dimorphism in colour pattern is common among iguanians (agamids, chamaeleonids, iguanids) and some scleroglossans (e.g., lacertids), with males often having bright display colours that are either subdued or lacking in females. However, not all these colour-pattern polymorphisms (e.g., among lacertids, see Arnold and Ovenden, 2002) are sexually dimorphic. Among skinks, dorsal colour-pattern polymorphisms appear infrequently. Several examples are known for Australian and Pacific skinks, including members of the genera *Carlia* (Greer, 1989), *Caledoniscincus*



(Sadlier, 1986; Sadlier *et al.*, 1999), *Celatiscincus* (Sadlier *et al.*, 2006), *Egernia* (Donnellan *et al.*, 2002; Chapple, 2003), *Emoia* (Bruna *et al.*, 1996), *Lamprolepis* (Perry and Buden, 1999; McCoy, 2006), *Lampropholis* (Greer, 1989; Forsman and Shine, 1995), *Lioscincus* (Sadlier and Bauer, 1999; Sadlier *et al.*, 2004), *Marmorosphax* (Sadlier and Bauer, 2000), and *Saproscincus* (Sadlier *et al.*, 1993). Most of these polymorphisms, however, are not of particularly striking appearance. They usually involve the presence or absence of longitudinal stripes, which may be of varying contrast and conspicuousness, or they involve distinct vs. no contrast between dorsal and lateral colour fields, or they comprise colour differences in an otherwise-conserved pattern (e.g., bright green vs. olive green vs. brown dorsum in *Lamprolepis smaragdina*). None involves such striking differences in colour pattern as described for the two *Prasinohaema* species above. That one of these striking polymorphisms should be sexually dimorphic, while the other is not, merely increases the biological interest of this already intriguing genus.

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# AN OBSERVATION OF DIURNAL BASKING IN THE TROPICAL AUSTRALIAN FROG *CRINIA BILINGUA*

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Diurnal activity is not uncommon in anurans *per se*, but has been reported for relatively few Australian frog species other than during heavily overcast and rainy conditions. Exceptions to this pattern include (amongst others) members of the genus *Taudactylus*. For example, *Taudactylus diurnus* from south-east Queensland takes its specific name from its exclusively diurnal activity pattern (Straughan & Lee, 1966). There are occasional literature references to diurnal basking in other Australian amphibians. For example, diurnal basking has been reported in *Cyclorana australis* and *Litoria dahlii* from the Barkley Tableland in the Northern Territory (Tyler *et al.*, 1983), *Litoria nannotis* in tropical Queensland (Hodgkinson & Hero, 2001) and *Litoria aurea* in New South Wales (Hamer *et al.*, 2002). We present an observation of diurnal basking in the Bilingual Froglet *Crinia bilingua*.

*Crinia bilingua* is a small (16–20 mm) myobatrachid frog restricted to the Kimberley region and Northern Territory through to the lower Gulf of Carpentaria (Cogger, 1996) where it is closely associated with marginal vegetation of temporary swamps and creeks (Barker *et al.*, 1994). Larval lifespan is 13–14 days (Martin *et al.*, 1980). To our knowledge there are no detailed, published accounts of any aspect of the ecology of this species.

In July 2008 whilst conducting baseline fauna surveys in the Victoria River Region of the Northern Territory (15°40'16"S 130°49'34"E, WGS84 datum), we repeatedly observed diurnal basking in *Crinia bilingua*. The species was recorded commonly on the periphery of permanent streams, particularly in association with *Pandanus aquaticus* (River Pandanus). Individual *Crinia bilingua* were recorded basking in full sunlight on exposed

rocks and open sections of stream banks, typically within a single leap of the water. When approached, individuals typically jumped into the stream and swam downstream from the initial location.

The observations are consistent with basking behaviour described in other species and may be driven by thermoregulatory demands of *C. bilingua* in the cooler months of the year. Observations were made between 0900 and 1500 hrs over several days and in different locations. The observations were recorded during July 2008, with a mean daily maximum of 29.9°C and mean daily minimum of 8.2°C observed at the Victoria River Downs meteorological station (Bureau of Meteorology, 2010). Whilst daily maximums may be considered relatively warm in temperate Australia, daily minimums were very low. In the study region, July is consistently the coldest month of the year and the period during which behavioural modulation of body temperature is least likely to be achieved by movement between microhabitats.

*Crinia bilingua* were observed basking in open positions in close proximity to water in this case, possibly as a strategy to reduce evaporative water loss by swimming frequently. Such behaviour has been reported for stream-dwelling tropical frogs in particular. With such a small body size, *C. bilingua* would have to enter the water frequently to maintain hydration.

Basking is often observed in Australian tree frogs in the family Hylidae, but appears to be much rarer in the Myobatrachidae (other than in *Taudactylus*). Many observations (including this observation) of basking in amphibians are of an anecdotal nature and lack sufficient data for proper interpretation. However, as

are no published accounts of basking in *Crinia*, this observation is considered to be of wider interest.

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# THE HERPETOFAUNA OF THE BIMBLE BOX-PINE WOODLANDS OF THE COBAR PENEPLAIN, WESTERN NSW

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## INTRODUCTION

The Cobar Peneplain is one of eighty biogeographic regions identified in Australia (Thackway & Creswell, 1995) and lies within the Central West of New South Wales, occupying over 73,000 square kilometres, or approximately one-tenth of the area of New South Wales (NPWS, 2000). It includes parts of the Western and Central Divisions, extending from near Bourke in the north, through to Griffith in the south, and includes the towns of Nymagee, Cobar, Nyngan, Condobolin and Lake Cargelligo. Only 2.49% of the bioregion is protected by conservation reserves (NPWS, 2003).

Currently the region largely supports dense shrub woodlands, with a shrubby understorey or herbs and grasses (CVMC, 2006). The most extensive vegetation community is bimble box-pine woodland (*Eucalyptus populnea* spp. *bimblii* – *Callitris glaucophylla*). Throughout much of its range, bimble box-pine woodland forms communities with and/or intergrades with other species such as red box (*Eucalyptus intertexta*), ironwood (*Acacia excelsa*), wilga (*Geijera parviflora*), belah (*Casuarina cristata*), rosewood (*Alectryon oleifolius*), leopardwood (*Flindersia maculosa*) and, infrequently, brigalow (*Acacia harpophylla*) (CVMC, 2006).

Despite bimble box-pine woodland being widespread, the paucity of published papers on the herpetofauna in this vegetation community suggests that little is known on distribution and status in the Cobar Peneplain Bioregion. Much of the knowledge of the herpetofauna of the region has been collected from within the mallee vegetation communities of the southern and western portions (Caughley, 1985; Cogger, 1969; Hallinger,

1993; Henle, 1987; Olsson *et al.*, 2005; Sass & Wilson, 2006; Schlesinger *et al.*, 1997).

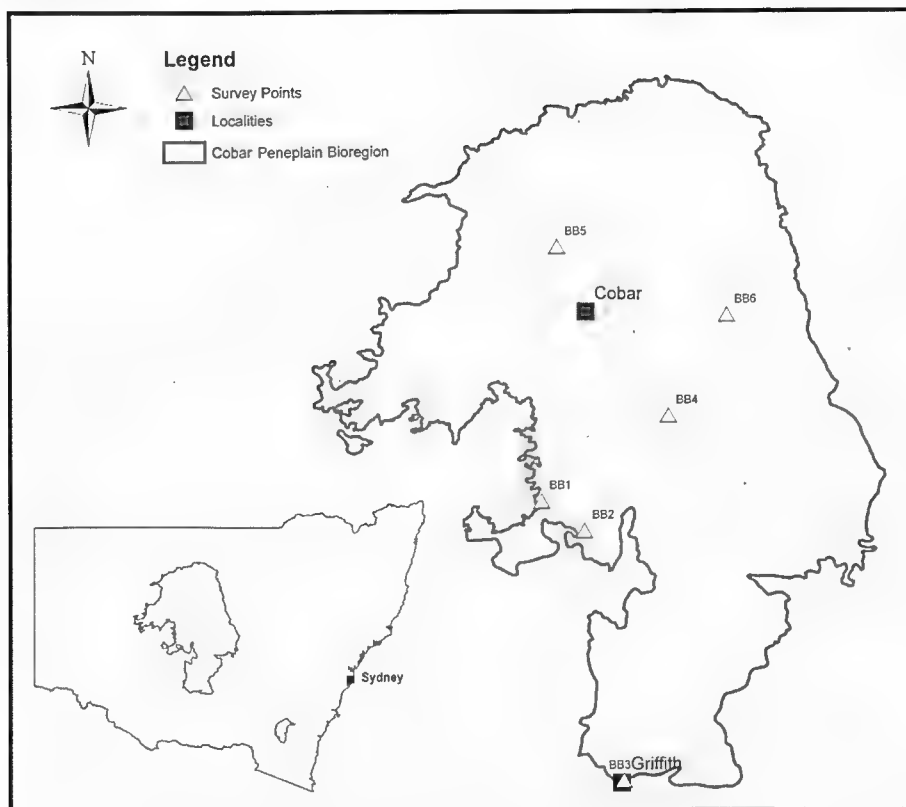
The aim of this paper is to document the herpetofauna that occur within bimble box-pine woodlands of the Cobar Peneplain bioregion from records of the authors and by conducting a review of previous literature relevant to this vegetation community. The conservation status of some species is also discussed.

## METHODS

The Cobar Peneplain region is well known to both authors, who have conducted numerous reptile surveys there since the 1980s. More specifically, six sites have been the subject of extensive herpetofauna surveys on numerous occasions, and their data provides an extensive list of species identified over a wide variety of seasons, years and micro-environmental conditions. These were at Yathong Nature Reserve (BB1), Nombinnie Nature Reserve (Sass, 2006; BB2), 2 km north of Griffith (BB3), 5 km south of Nymagee (BB4), 50 km north of Cobar (BB5) and 50 km east of Cobar (BB6) (Figure 1). This wide variation in both environmental conditions and spatial distribution provides a comprehensive list of herpetofauna species that have been recorded in this vegetation community within the bioregion. Each of the six locations was characterised by bimble box-pine woodland (*Eucalyptus populnea* spp. *bimblii* – *Callitris glaucophylla*) with scattered stands of red box (*Eucalyptus intertexta*). Lower shrubs were dominated by budda (*Eremophila mitchelli*) and turpentine (*Eremophila sturtii*) whilst forbs and grasses were dominated by native species.

Each study site was also characterised by different land management regimes. Of the six

**Figure 1. Location of the Cobar Penneplain Bioregion and the survey locations**



sites, two are nature reserves under the management of the Department of Environment and Climate Change (DECC) (BB1, BB2), one site is crown land (BB3) and the remaining three are on private property (BB4, BB5, BB6) (Figure 1). Data collected from these sites was undertaken using various methods including pitfall traps using 20 L buckets and drift fences, Elliot traps baited with a mixture of peanut butter, honey and rolled oats, systematic searches where active animals were located visually, while inactive animals were located by lifting loose rocks, viewing hollow logs, searches of rock and tree crevices, old sheets of corrugated iron and leaf litter. Frog species were identified by spotlighting, listening for calls and conducting call playback to

encourage non-calling frogs to respond at drainage lines, earthen tanks and domestic water tanks. Not all methodologies were used at every site. Opportunistic records were also collected by the authors while driving through this vegetation community before, during and after surveys.

Searches were made of scientific journal databases, the world-wide web, and other relevant data where surveys have been undertaken specifically in bumble box-pine woodland to provide additional information on the herpetofauna of the region.

Discussions with land managers and farm workers were undertaken to determine addi-

tional species that may not have been encountered during surveys. Due to the difficulties that inexperienced people have in identifying many species of reptile and frog, only species that are easily identified were considered.

Nomenclature and common names follow Swan *et al.* (2004) and Anstis (2002) except for *Lerista muelleri* and *Cryptoblepharus carnabyi*. *Lerista muelleri* has recently been revised, and the species in New South Wales is now *Lerista timida* (Hutchinson, 2008). Similarly, the population previously assigned to *Cryptoblepharus carnabyi* in inland New South Wales is now either *Cryptoblepharus pannosus* or *C. australis* (Horner, 2007). As we have not been able to examine specimens of *Cryptoblepharus* from the study sites since these two species were described, all records have been grouped as *Cryptoblepharus* sp. in this paper.

## RESULTS

Collation of the authors' records identified a total of 33 species of reptile and 10 species of frog within bumble-box woodlands of the Cobar Penepine Bioregion (Table 1).

During our search of the literature, two large-scale fauna studies were identified from within a large number of vegetation communities of the Cobar Penepine bioregion including bumble box-pine woodlands (Masters & Foster, 2000; NPWS, 2001). These studies found 25 species of reptile and 8 species of frog within bumble-box pine woodlands (Table 2).

Discussions with land managers and farm workers during 2003 surveys at BB4 revealed the presence of three additional reptile species: *Morelia spilota metcalfei*, *Vermicella annulata* and *Acanthophis antarcticus*. All three species are considered by the authors to be easily identifiable by persons unfamiliar with reptiles, and so it is with a high level of accuracy that these data can be included.

The inclusion of data from all of these sources

brings the total number of species recorded in bumble-box pine woodlands to 40 species of reptile and 11 species of frog (Table 2).

## DISCUSSION

The diverse landscape and vegetation of the Cobar Penepine bioregion is already known to support a wide variety of vertebrate fauna species (NPWS, 2003). This study has identified that the bumble box-pine woodlands of the bioregion support a high level of diversity of herpetofauna species with 51 species recorded to date (Table 2).

Five species of reptile (two species of lizard - *Ctenophorus pictus*, *Egernia modesta*, and three species of snake - *Acanthophis antarcticus*, *Pseudonaja textilis*, *Vermicella annulata*) and two species of frog (*Crinia parinsignifera*, *Uperoleia rugosa*) were only recorded at single locations. Sadler and Pressey (1994) reviewed the herpetofauna of western NSW and identified *Egernia modesta* and *Acanthophis antarcticus* as likely to be of conservation concern.

*Ctenophorus pictus* is widespread through the region but is more usually associated with mallee/spinifex habitats or shrublands. The single record occurred at BB5, and only one individual was sighted. Rocky outcrops dominated the area where this individual was sighted, which is unusual for this species. Despite additional searches, no further individuals were recorded. It is likely that this species occurs only in very low abundance at scattered bumble-box pine woodland locations across the bioregion.

*Egernia modesta* is distributed through the northern tablelands south to the Hunter Valley and also on the north-west slopes. At the western limit of the species distribution isolated populations occur near Walgett and at Yathong Nature Reserve. The Yathong individuals were found on the Murrumbidgee Range in 1980. Since then extensive field work in this Reserve across a range of other habitats has failed to record further individuals of *E. modesta*, and it would appear it is most likely

**Table 1. Reptiles and frogs recorded by the authors in bimble box-pine woodland of the Cobar Peneplain.**

BB1 = Yathong NR, BB2 = Nombinnie NR, BB3 = Griffith, BB4 = Nymagee, BB5 = Cobar, BB6 = Hermidale (\* = recorded by authors, A = anecdotal record).

Scientific name	Common name	BB1	BB2	BB3	BB4	BB5	BB6
<b>REPTILIA</b>							
<b>Gekkonidae</b>							
<i>Diplodactylus vittatus</i>	Eastern Stone Gecko				*		*
<i>Gehyra dubia</i>	Dubious Dtella	*					
<i>Gehyra variegata</i>	Common Dtella	*		*	*	*	*
<i>Heteronotia binoei</i>	Prickly Gecko	*	*		*	*	*
<i>Rhynchoedura ornata</i>	Beaked Gecko		*		*		
<i>Strophurus intermedius</i>	Southern Spiny-tailed Gecko	*	*	*	*	*	*
<i>Underwoodisaurus milii</i>	Thick-tailed Gecko	*			*		
<b>Varanidae</b>							
<i>Varanus gouldii</i>	Sand Goanna		*	*	*		*
<i>Varanus varius</i>	Lace Monitor	*	*		*	*	*
<b>Agamidae</b>							
<i>Amphibolurus nobbi coggeri</i>	Nobbi Dragon		*		*		
<i>Ctenophorus pictus</i>	Painted Dragon					*	
<i>Pogona vitticeps</i>	Central Bearded Dragon	*	*	*	*	*	*
<b>Scincidae</b>							
<i>Cryptoblepharus</i> , sp.	Wall Lizard	*	*	*	*	*	*
<i>Ctenotus allotropis</i>		*	*		*		
<i>Ctenotus regius</i>	Royal Ctenotus					*	
<i>Ctenotus robustus</i>	Robust Ctenotus	*	*		*	*	*
<i>Ctenotus schomburgkii</i>			*			*	
<i>Egernia modesta</i>		*					
<i>Egernia striolata</i>	Tree Skink	*			*	*	*
<i>Lerista timida</i>	Three-toed Lerista	*		*	*		*
<i>Lerista punctatovittata</i>	Spotted Lerista	*			*		*



Scientific name	Common name	BB1	BB2	BB3	BB4	BB5	BB6
<b>REPTILIA</b>							
<b>Scincidae (cont.)</b>							
<i>Menetia greyii</i>	Common Dwarf-skink				*	*	
<i>Morethia boulengeri</i>	Boulenger's Morethia	*	*	*	*	*	*
<i>Tiliqua scincoides</i>	Eastern Blue-tongue	*	*	*	*		*
<i>Tiliqua rugosa</i>	Shingleback	*	*	*	*	*	*
<b>Pythonidae</b>							
<i>Morelia spilota metcalfei</i>	Inland Carpet Python	*			A		A
<b>Elapidae</b>							
<i>Acanthophis antarcticus</i>	Common Death Adder				A		
<i>Demansia psammophis</i>	Yellow-faced Whipsnake				*		*
<i>Pseudechis australis</i>	Mulga Snake				*	*	*
<i>Pseudonaja nuchalis</i>	Western Brown Snake	*			*		*
<i>Pseudonaja textilis</i>	Eastern Brown Snake				*		
<i>Suta dwyeri</i>	Dwyer's Black-headed Snake	*	*		*	*	*
<i>Vermicella annulata</i>	Bandy-bandy				A		
<b>AMPHIBIA</b>							
<b>Hylidae</b>							
<i>Litoria caerulea</i>	Green Tree Frog				*	*	*
<i>Litoria peronii</i>	Peron's Tree Frog	*	*		*	*	*
<i>Litoria rubella</i>	Desert Tree Frog	*	*		*	*	*
<b>Myobatrachidae</b>							
<i>Crinia parinsignifera</i>	Eastern Sign-bearing Frog			*			
<i>Limnodynastes fletcheri</i>	Fletcher's Frog						*
<i>Limnodynastes interioris</i>	Giant Bullfrog				*		*
<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog				*		*
<i>Neobatrachus sudelli</i>	Painted Burrowing Frog		*	*	*	*	*
<i>Notaden bennettii</i>	Holy Cross Toad		*	*	*		
<i>Uperoleia rugosa</i>	Wrinkled Toadlet						*

**Table 2. Reptiles and frogs recorded in bimbie box-pine woodland across the Cobar Penneplain by the authors (SaSw), NPWS (2001) and Masters and Foster (2000) (NPMF)(\* = Recorded).**

Scientific name	Common name	SaSw	NPMF
<b>REPTILIA</b>			
<b>Gekkonidae</b>			
<i>Diplodactylus tessellatus</i>	Tessellated Gecko		*
<i>Diplodactylus vittatus</i>	Eastern Stone Gecko	*	*
<i>Gehyra dubia</i>	Dubious Dtella	*	*
<i>Gehyra variegata</i>	Common Dtella	*	*
<i>Heteronotia binoei</i>	Prickly Gecko	*	*
<i>Lucasium damaeum</i>	Beaded Gecko		*
<i>Lucasium steindachneri</i>	Box-patterned Gecko		*
<i>Rhynchoedura ornata</i>	Beaked Gecko	*	
<i>Strophurus intermedius</i>	Southern Spiny-tailed Gecko	*	*
<i>Underwoodisaurus milii</i>	Thick-tailed Gecko	*	*
<b>Varanidae</b>			
<i>Varanus gouldii</i>	Sand Goanna	*	*
<i>Varanus tristis tristis</i>	Black-headed Monitor		*
<i>Varanus varius</i>	Lace Monitor	*	*
<b>Agamidae</b>			
<i>Amphibolurus nobbi coggeri</i>	Nobbi Dragon	*	*
<i>Ctenophorus nuchalis</i>	Central Netted Dragon		*
<i>Ctenophorus pictus</i>	Painted Dragon	*	
<i>Pogona barbata</i>	Eastern Bearded Dragon		*
<i>Pogona vitticeps</i>	Central Bearded Dragon	*	*
<b>Scincidae</b>			
<i>Cryptoblepharus sp.</i>	Wall Lizard	*	*
<i>Ctenotus allotropis</i>		*	*
<i>Ctenotus leonhardii</i>			*
<i>Ctenotus regius</i>	Royal Ctenotus	*	
<i>Ctenotus robustus</i>	Robust Ctenotus	*	
<i>Ctenotus schomburgkii</i>		*	
<i>Egernia modesta</i>		*	

Scientific name	Common name	SaSw	NPMF
<b>REPTILIA</b>			
<b>Scincidae (cont.)</b>			
<i>Egernia striolata</i>	Tree Skink	*	*
<i>Lerista timida</i>	Three-toed Lerista	*	*
<i>Lerista punctatovittata</i>	Spotted Lerista	*	*
<i>Menetia greyii</i>	Common Dwarf-skink	*	
<i>Morethia boulengeri</i>	Boulenger's Morethia	*	*
<i>Tiliqua scincoides</i>	Eastern Blue-tongue	*	
<i>Tiliqua rugosa</i>	Shingleback	*	*
<b>Pythonidae</b>			
<i>Morelia spilota metcalfei</i>	Inland Carpet Python	*	
<b>Elapidae</b>			
<i>Acanthophis antarcticus</i>	Common Death Adder	*	
<i>Demansia psammophis</i>	Yellow-faced Whip Snake	*	
<i>Pseudechis australis</i>	Mulga Snake	*	*
<i>Pseudonaja nuchalis</i>	Western Brown Snake	*	
<i>Pseudonaja textilis</i>	Eastern Brown Snake	*	
<i>Suta dwyeri</i>	Dwyer's Black-headed Snake	*	
<i>Vermicella annulata</i>	Bandy-bandy	*	
<b>AMPHIBIA</b>			
<b>Hylidae</b>			
<i>Litoria caerulea</i>	Green Tree Frog	*	*
<i>Litoria latopalmata</i>	Broad-palmed Frog		*
<i>Litoria peronii</i>	Peron's Tree Frog	*	*
<i>Litoria rubella</i>	Desert Tree Frog	*	*
<b>Myobatrachidae</b>			
<i>Crinia parinsignifera</i>	Eastern Sign-bearing Frog	*	
<i>Limnodynastes fletcheri</i>	Fletcher's Frog	*	*
<i>Limnodynastes interioris</i>	Giant Bullfrog	*	*
<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog	*	*
<i>Neobatrachus sudelli</i>	Painted Burrowing Frog	*	*

Scientific name	Common name	SaSw	NPMF
<b>AMPHIBIA</b>			
<b><i>Myobatrachidae (cont.)</i></b>			
<i>Notaden bennettii</i>	Holy Cross Toad	*	
<i>Uperoleia rugosa</i>	Wrinkled Toadlet	*	

limited to stony outcrops of the range. Considering that the species is regarded as being of conservation concern in the Western Division (Sadler & Pressey, 1994) and that the Yathong population is disjunct from other known populations, further investigation as to the current status of the Yathong population should be given the highest priority. Natural resource managers of this reserve should have the highest regard for the presence of this species on the Merrimerrriwa Range when considering any actions that may impact on its survival such as fire management and feral goat control.

*Acanthophis antarcticus* is known only from a very old record at Cobar (Swan *et al.*, 2004) and anecdotal accounts from workers at site BB4. This species is apparently very uncommon in the region and possibly only survives in isolated rocky outcrops that have not been degraded by feral goats. Extensive searches were undertaken during two week-long surveys over one year where a landholder reported seeing a large (~1 m) individual, with no success. However, De Vis' Banded snakes (*Denisonia devisi*) are sometimes mistaken by land owners as young death adders, so unsupported reports need to be treated with caution.

*Pseudonaja textilis* was only recorded from one of the six sites investigated. It is widespread throughout New South Wales although there are very few records from the Cobar Penepplain (Swan *et al.*, 2004). Given that there is no shortage of Western Brown Snake records from the region perhaps this species is genuinely uncommon.

*Vermicella annulata* is probably uncommon in the region, although its cryptic habits make it notoriously difficult to locate. Despite this,

extensive surveys by the authors over a long period of time in the bioregion have not revealed this species within bumble box-pine woodland. Indeed, the single record of this species was provided by a landholder.

Both species of frog (*Crinia parinsignifera* and *Uperoleia rugosa*) would appear to be on the edge of their natural distribution within the bioregion (Anstis, 2002). In this case, it would be expected that such species would occur in low abundance and scattered populations.

This paper presents an updated inventory for herpetofauna across the most widespread vegetation community of the Cobar Penepplain bioregion. The relatively high diversity of herpetofauna suggests that bumble box-pine woodland should not be underestimated in terms of landscape-scale biodiversity conservation. The presence of *Egernia modesta* in the bioregion should be regarded as significant and warrants urgent further investigation.

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# PREDATION OF A DESERT SKINK, *LIOPHOLIS INORNATA*, AND BURROW OCCUPATION BY A RINGED BROWN SNAKE, *PSEUDONAJA MODESTA*

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## INTRODUCTION

A higher proportion of saurophagous (lizard-eating) snake species occur in Australia than in other parts of the world where large numbers of dietary studies on snakes have been undertaken, including Africa, China and North America (Shine, 1977). Skinks (family Scincidae) feature prominently in the diets of many Australian front-fanged venomous land snakes (family Elapidae), while lizards belonging to other families including legless lizards, geckos, dragons and monitors appear to be less frequently consumed (Shine, 1991).

Here I document the predation of a Desert Skink *Liopholis inornata* and burrow occupation by a Ringed Brown Snake *Pseudonaja modesta* (Elapidae), observed during a study on *L. inornata* at Gluepot Reserve in South Australia.

*Liopholis inornata* is a small-moderate sized (SVL 84 mm) crepuscular to nocturnal skink which occurs in arid and semi-arid parts of southern Australia, from Thrushton National Park in Queensland to Shark Bay in Western Australia (Wilson & Swan, 2010). It is an effective burrower, constructing burrow systems around which much of its daily activity is centered (Daniel, 1998). The typically 'U' shaped burrows often consist of one tunnel with a distinctive layer of sand fanning out from a single entrance (Pianka & Giles, 1982), although some burrows are more complex, consisting of several tunnels and multiple entrances (Daniel, 1998). One arm of the burrow usually terminates just below the substrate surface, possibly for use as an

escape route when pursued by predators (Pianka & Giles, 1982), and individuals may use several burrows concurrently, rotating between them (Pianka, 1986; Griffin, 1997; Daniel, 1998; De Angelis, 2009).

As well as providing an effective escape from predators, burrows are likely to provide *L. inornata* with protection from fire and allow individuals to persist in recently burnt areas, provided that sufficient resources are available for their continued survival. *Liopholis inornata* has shown trends towards greater abundance at recently burnt sites (2-7 years post-fire) compared to longer unburnt sites (>18 years post-fire) (Sass & Wilson, 2006; Driscoll & Henderson, 2008; De Angelis, 2009).

The Ringed Brown Snake *Pseudonaja modesta* is the smallest known species of *Pseudonaja*, growing to <1 m in length (Shine, 1989). It has a distribution largely overlapping in the southern parts of its range with that of *L. inornata*, and has been recorded sheltering under ground debris and amongst porcupine grass *Triodia* spp. (Cogger, 2000). *Pseudonaja modesta* is known to be largely saurophagous, with a significant portion of its diet consisting of small skinks, geckos and dragons (Shine, 1989).

## METHODS

The study took place during the spring-summer of 2008-2009 in the Birdseye Reference Area (33°45'S 140°18'E), approximately 65 km north of the town of Waikerie in South Australia's Riverland District. The one hectare

study site was located on a sand dune that had been burnt during a wildfire in November 2006, with few logs or other ground debris present and sparse vegetation dominated by small (<20 cm diameter) regenerating *Triodia* and coppicing *Eucalyptus* spp. Burrow entrances belonging to *L. inornata* and other species including the Sand Goanna *Varanus gouldii* and Inland Robust Scorpion *Urodacus yaschenkoii* were identified, and twelve entrances belonging to *L. inornata* were targeted for trapping using plant pots (18 x 19 cm). Each plant pot was dug into the ground outside a burrow entrance and inspected three times a day over three days.

On 5 January 2009, a gravid female Desert Skink weighing 13 g was captured and a radio transmitter (model LTM, Titley Electronics) weighing 0.5 g was attached to its back using surgical glue (Histoacryl, B. Braun). The skink was then released back outside its burrow and subsequently located three times a day (at approximately 0800, 1900 and 2100 hrs) over six days.

## OBSERVATIONS

On the first day of tracking, the transmitter, presumably with the skink still attached, was tracked to another *L. inornata* burrow 6 m away from the burrow from which it was captured. The signal was subsequently followed back to this burrow each time radio tracking was undertaken. At approximately 0730 hrs on 12 January, the burrow was carefully excavated using a hand trowel and soil scoop to retrieve the transmitter. The radio receiver was switched on and the antenna held to the ground above the burrow to keep track of the transmitter while digging. The signal strength from the transmitter gradually dropped as the burrow was excavated and was lost by the time the bottom of the burrow was reached.

After the receiver antenna was lifted from the ground, a faint signal was again detected and followed in an easterly direction before fading. When the antenna was turned in the opposite direction, the signal strength climbed. On looking down, a Ringed Brown

Snake approximately 40 cm long was seen moving on the surface. The signal became stronger when the receiver antenna was pointed in the direction of the snake, and dropped when the antenna was pointed away from it. It was then concluded that the snake had consumed the skink with the transmitter attached.

The snake was followed for several metres before it entered another burrow belonging to a Desert Skink. This burrow was revisited on several occasions to determine whether the snake had changed location, but no further movements were recorded. On 25 January, the burrow was excavated and the transmitter retrieved after having been excreted by the snake which had since left.

## DISCUSSION

Snakes in the genus *Pseudonaja* have previously been reported to prey on other burrowing lizards (e.g. Jones, 1990; Shine, 1989), and other elapids are known to have preyed on several congeners of *Liopholis inornata*, including *L. whitii* (Shine, 1987a), *L. margaretae* (Shine, 1987b), *L. guthega* (Donnellan *et al.*, 2002) and *L. multiscutata* (Schwaner, 1985). Daniel (1998) observed snakes thought to be King Brown Snakes *Pseudechis australis* investigating burrows belonging to *L. inornata*, and noted that scars on several *L. inornata* from the Eyre Peninsula were most likely to be from predation attempts by snakes or Sand Goannas. These observations as well as that made during the current study suggest that snakes may be significant predators of *L. inornata* and its congeners.

Desert Skinks are known to be wary of predators and have been observed fleeing into their burrows in response to disturbances such as birds flying overhead (Webber, 1978), although such a response may do little to deter terrestrial predators such as snakes. Daniel (1998) observed one snake blocking off entrances to a multi-entranced burrow with its body while looking down the remaining entrance. Having one arm of the burrow

terminate just below the substrate surface for use as an escape route may reduce the effectiveness of these sorts of predation attempts. The movement of *L. inornata* between different burrows may be another strategy to reduce encounters with predators such as snakes, as well as avoiding parasite infestations and increasing access to food resources (Daniel, 1998).

*Pseudonaja modesta* consumes fewer mammals than any of its congeners, feeding almost exclusively on lizards, and it is thought that the small body size of *P. modesta* may preclude it from feeding on mammalian prey (Shine, 1989). The apparent abundance of *L. inornata* at recently burnt sites is likely to provide a reliable food source for *P. modesta* where other prey items might be scarce. As observed during this study, *L. inornata* may not only be of value as a food source for *P. modesta* in recently burnt areas, but also provide an escape from predators and extremes in temperature through the provision of burrows in areas where above-ground refuges such as logs and mature *Triodia* are scarce.

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# A NEWLY DISCOVERED POPULATION OF THE ENDANGERED TAWNY ROCK DRAGON *CTENOPHORUS DECRESII* IN FAR WESTERN NSW AND A DESCRIPTION OF ITS HABITAT

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## INTRODUCTION

The Tawny Rock Dragon *Ctenophorus decresii* is a small agamid measuring 8 cm long (snout to vent) and can be found in rocky outcrops and gorges in inland southern Australia (Wilson & Swan, 2008) (Figure 1). In New South Wales, the species was previously known from populations located within and adjacent to Mutawintji National Park, a single specimen from Koonenberry Mountain (north of Mutawintji) lodged with the Australian Museum, and reportedly from rocky outcrops between the South Australian Border and Broken Hill (Swan & Foster, 2005).

The Tawny Rock Dragon is listed as Endangered under the NSW Threatened Species Conservation Act 1995 following a determination by the NSW Scientific Committee in 2001 (DECCW, 2010). Key factors in this determination included their extremely restricted distribution in NSW and the likely degradation of these habitats by introduced herbivores such as feral goats.

This paper records a newly discovered population of the Tawny Rock Dragon in far western NSW and discusses some aspects of their habitat.

## METHODS

General biodiversity surveys were undertaken between September 2007 and November 2008 across approximately 30,000 hectares as part of the environmental assessment for the recently approved Silverton Wind Farm, approximately 35 kilometres north west of Broken Hill (31°47'21"S 141°15'47"E) in far-

western NSW (see [nghenvironmental, 2008a,b](#) for details).

Target reptile surveys for the Tawny Rock Dragon were undertaken as the species was predicted to occur in the region (DECC, 2010) and the habitat was similar in some aspects to that at Mutawintji National Park with rocky hills and outcropping covered in semi-arid shrublands. Given that previous records at Mutawintji were the result of opportunistic observations rather than by targeted trapping (Swan & Foster, 2005), transects were conducted either on foot, or by a vehicle slowly driving on tracks within the study area (after Blomberg & Shine, 1996) using teams of two persons; each team comprising an experienced herpetologist and an ecologist. Both observers visually scanned areas of potential habitat using high-powered binoculars seeking active animals (i.e. engaged in display, combat, foraging or movement) and inactive animals (basking or resting). Survey areas were only visited on one occasion. Additional surveys were also undertaken in the wider locality at a number of publicly accessible locations.

A series of qualitative and quantitative data was collected on habitat at each site where the Tawny Rock Dragon was recorded. Whilst analysis of these data will be the subject of a future manuscript, some details are provided here.

## RESULTS

Surveys to date have revealed a total of 209 Tawny Rock Dragons inhabiting the study area. These records are scattered across an

area of around 30,000 hectares. As surveyed areas were only visited on one occasion, the authors are reasonably confident that this number does not include any re-sighted individuals. Further detail on search effort, number of individuals recorded during each survey and detectability are provided (Table 1). Previous records for this species as well as the location of the new population are shown in Figure 2.

All Tawny Rock Dragons recorded were located on the main ridge systems that comprise the study area. The majority of these were found on the flatter tops of ridges (67%) with the remainder on the downslope away from the ridge top and in one case, in a creek gully. Individuals were more often recorded on an aggregation of rocks (89% of records) than a single, isolated rock. Along existing vehicular tracks, 15 individuals were observed displaying or basking on the road spoil. Four sites presented evidence (visual observation) of co-occurrence with another rock-obligate species, the Gidgee Skink *Egernia stokesii*. Locality searches failed to reveal the presence of Tawny Rock Dragon beyond the boundaries of the study area.

DISCUSSION

Prior to our first surveys of the study area in September 2007, the only known records of the Tawny Rock Dragon were significant populations at Mutawintji National Park, Coturaundee Nature Reserve, and Rampart Hills on Waterbag Station adjacent to Mutawintji

(120 km to the north-east of the study area) (Swan & Bonnett, 2001), a single museum specimen from Koonenberry Mountain (north of Mutawintji) and reportedly from rocky ranges between Broken Hill and the SA border (Swan & Foster, 2005). Surveys at Mutawintji have revealed fewer than 50 animals combined (Swan & Foster, 2005) making this new population the largest known in NSW. These sites range from between 140 km and 30 kms from the study area. Subsequent searches of the latter sites have not revealed any Tawny Rock Dragons despite the species being conspicuous where it is present (Swan & Foster, 2005). Given their moderately restricted national distribution (Sadler & Pressey, 1994), this newly identified population of the endangered Tawny Rock Dragon should be regarded as the major population of this species in NSW.

Habitat for the Tawny Rock Dragon in the study area is characterised by Mulga shrublands dominated by Mulga *Acacia aneura* and Dead Finish *Acacia tetragonophylla*, and Black Oak woodland dominated by Black Oak *Casuarina pauper* and Western Rosewood *Alectryon oleifolius*. A previously unknown vegetation community described by Benson and Sass (2008) which was recently listed as a Critically Endangered Ecological Community under the NSW *Threatened Species Conservation Act 1995*, Porcupine Grass – Red Mallee – Gum Coolabah hummock grassland / low sparse woodland (DECC, 2010) also provides habitat for the Tawny Rock Dragon in the study area. This

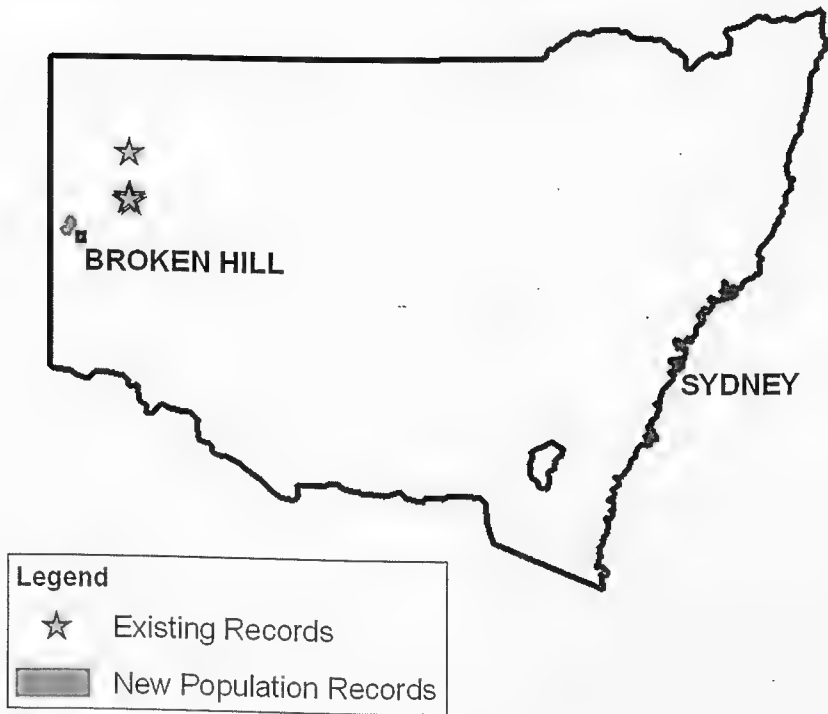
**Table 1: Summary of Survey effort including the detectability rate of Tawny Rock Dragon (Ind = number of individuals recorded, Det = search time in hours to detect one individual)**

Sep 2007			Nov 2007			Sep 2008			Nov 2008		
Survey effort (hrs)	Ind	Det	Survey effort (hrs)	Ind	Det	Survey effort (hrs)	Ind	Det	Survey effort (hrs)	Ind	Det
20	1	20	160	35	4.57	27	12	2.25	171	161	1.062

**Figure 1: A male Tawny Rock Dragon in breeding colours displaying on a rocky outcrop north-west of Broken Hill, NSW. Photo: Steve Sass.**



**Figure 2: Existing records of the Tawny Rock Dragon and the new population north-west of Broken Hill, far western NSW.**



vegetation community is dominated by mallee eucalypts and a spinifex understorey covering around 80% of ground cover with the remainder being rocky outcrops and a variety of chenopods and grasses. The rock-obligate nature of the species was confirmed in our study with most individuals recorded on aggregations of rocks.

Detection of the Tawny Rock Dragon during this study was influenced by increased temperature and breeding associated activity such as male display. The territorial nature of males (Osborne, 2005) making this species very visible on rock outcropping during hot weather where they were observed using these high vantage points for display purposes. The search effort required during the first November survey was high with the species

not found in large areas of apparently suitable habitat. During the second November survey, large numbers of individuals were easily observed with males perching on rocky outcrops and defending territories against rival males. Females were also observed in close proximity to males and between male territories.

Faunal distribution patterns are known to be influenced by resource availability and populations are not distributed evenly across landscapes (Dickman *et al.*, 2001, James, 1991, James & Shine, 2000, Morton & James, 1988). For the Tawny Rock Dragon, the patchy distribution across the study area and their absence from seemingly suitable habitat may be a result of such resource patchiness.

The NSW Scientific Committee has listed 'Competition and habitat degradation by Feral Goats' as a Key Threatening Process. Twenty-three threatened species were listed in the Committee's determination as being at risk due to this process, including the Tawny Rock Dragon (DECC, 2010). The impacts of heavy grazing by any stock is already known to be detrimental to many reptile species (Fischer *et al.*, 2004; Hadden & Westbrooke, 1996; Sadler & Pressey, 1994; Wassens *et al.*, 2005) and this is also likely to be the case for Tawny Rock Dragon. Hadden and Westbrooke (1996) found that reptiles were affected by changes in vegetation structure from overgrazing, as these reduce microhabitat availability and subsequently habitat quality. Specific to the Western Division, Sadler and Pressey (1994) identified that grazing is likely to adversely affect reptile species in the long-term.

As there are no long-term data on feral goats or this newly discovered population of Tawny Rock Dragon, it is difficult to gain a detailed understanding of the likely impacts of feral goats given that both are cohabitating the study area. However, feral goats have already been identified as the cause of degradation of habitats for other rock-crevice specialists such as the Broad-headed snake (*Hoplocephalus bungaroides*) (Murphy, 1996) and the western NSW population of the plain-backed morph of White's Skink (*Egernia whitii*) (formerly identified as the Centralian Ranges Rockskink *Egernia margaretae*; NPWS, 2000).

Competition with other rock-obligate reptile species for crevices is known to be highly correlated with species' body size in creating a dominance hierarchy (Langkilde & Shine, 2004). All locality searches and more than 98% of the sites where Tawny Rock Dragon was present in the study area failed to find co-existence between the two rock-obligate species. This agrees with Swan and Bonnett's (2001) observation that they never found Gidgee Skinks and Tawny Rock Dragons together during their surveys in Mutawintji National Park and other areas.

This newly discovered and large population of the Tawny Rock Dragon provides a unique opportunity to gain a greater understanding of the species through research, monitoring and long-term management.

## ACKNOWLEDGMENTS

We wish to thank all persons who assisted with the field surveys for the Tawny Rock Dragon. We also would like to thank the landholders for their hospitality and their orientation around such a large study area.

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All surveys were conducted under Department of Environment & Climate Change Scientific licence and a Department of Primary Industries Animal Care and Ethics determination.

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**OBSERVATIONS OF THE HEATH MONITOR  
*VARANUS ROSENBERGI* (VARANIDAE):  
A RECORD FROM GAMBO HILL NEAR RYLSTONE, NEW SOUTH WALES**

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*Varanus rosenbergi* is a medium to moderately large, terrestrial monitor with a more southerly distribution than most other varanids. It is adapted to the cooler areas of southern Australia, being generally darker than the closely related *V. gouldii* (Ehmann, 1992; Anon, 2009). The distribution extends from southern Western Australia, through South Australia and Kangaroo Island, with a disjunct distribution in Victoria and the south-eastern areas of New South Wales, predominantly east of the Great Dividing Range (Ehmann, 1992; Cogger, 2000; Swan *et al.*, 2004; DECCW, 2005; Wilson & Swan, 2008).

This note records an extended sighting of an individual of this species representing a north-western extension of the reported distribution in New South Wales (Figure 1). The sighting was made on a property east of Rylstone, NSW (32°44'36.44"S 150°09'34.27"E; 720 m above sea level; source: Google Earth Ver.4.3.7191). The property encompasses Gambo Hill on the north-western edge of the Wollemi National Park and is crossed by Cox's Creek, a tributary of the Cudgegong River. The land was totally cleared of timber approximately 15-20 years ago, and now consists of 34 ha of regrowth open dry sclerophyll woodland with a further 6 ha of open grassy area around the dwelling. The northern boundary of the property, atop Gambo Hill, adjoins Wollemi National Park.

The monitor (Figures 2-3), which was around 1-1.2 m in total length (SVL approx. 500-600 mm), approached the house from the south-west (i.e., away from the National Park) at 1330 hrs on 28 November 2009. The weather was fine with a dust haze in the air. Ambient temperature was approximately 32-35°C.

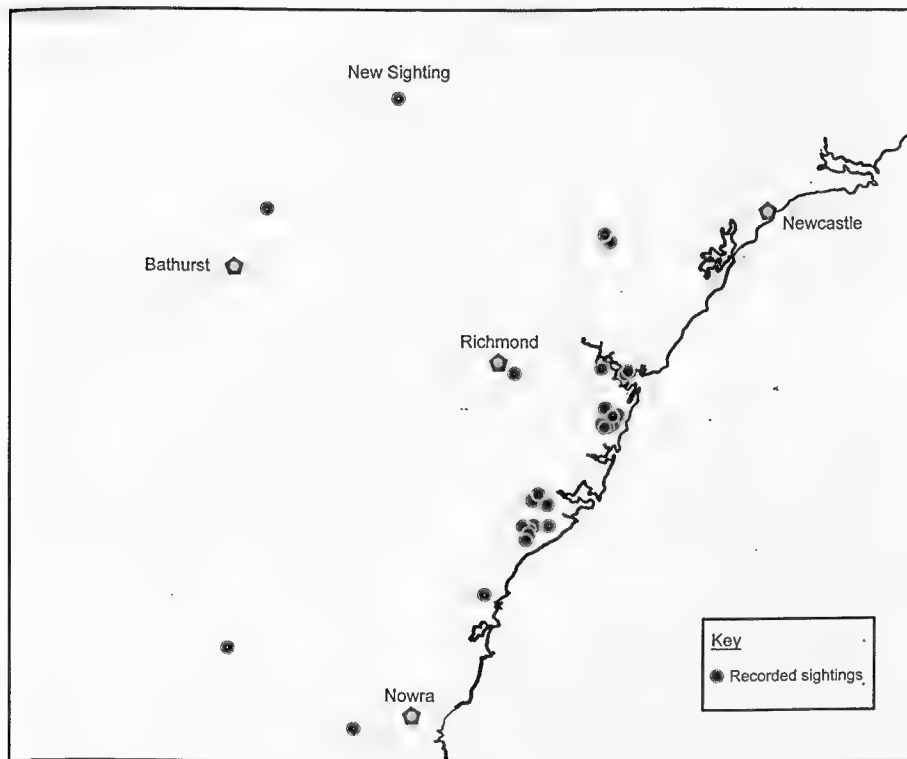
The animal showed little fear of the dwelling and its occupants and casually sauntered over to the entry of a rabbit warren beside the house, slipped into the hole and, after about 3 minutes, returned with a freshly killed young rabbit (approximately 150-200 mm SVL) in its mouth. Figure 4 shows the relative size of monitor to prey item. The monitor then dismembered and devoured the entire carcass over a period of about 20-30 minutes. During this period the monitor was alert to our presence but unaffected, stopping briefly at the sound of the digital camera and continuing with the meal regardless. After cleaning up the entrails, the monitor went back into the warren, coming out 'empty handed' then strolled slowly away, stopping every so often to fossick in the leaf litter and apparently take some small insects.

There is an abundance of rabbit (*Oryctolagus cuniculus*) warrens and wombat (*Vombatus ursinus*) burrows in the area offering a multitude of shelter sites for *V. rosenbergi*, as they often utilise these instead of digging their own (King & Green, 1999). This sighting also confirms that rabbits and their young, which are abundant locally, are prey items for *V. rosenbergi*. There are also many termite mounds scattered throughout the region, offering nesting sites for these monitors (Ehmann *et al.*, 1991).

The presence of both *V. rosenbergi* and rabbits locally raises another concern, the possible death of the goannas from inadvertent poisoning. The area surrounding Gambo Hill and Rylstone is inhabited by many pest species including introduced mice and rats, rabbits, fox, wild dogs and feral cats. The use of 1080 (sodium fluoroacetate) in species-specific baits is common, and monitors could



**Figure 1. NSW records of *Varanus rosenbergi*, including the new sighting. Compiled from Australian Museum records.**



take poisoned carrion or poorly set baits. The use of baits for wild dogs is widely signposted in the area and is of possible concern for *V. rosenbergi* as they have an exceptional olfactory sense and are quite adept at digging, which could see them obtaining poorly buried baits. Twigg *et al.* (2009) suggest the shallow burial or tethering of baits to reduce risks to non-target species. The effectiveness of this practice is dubious in the case of varanids with their capacity for following scents and for digging. The poison 1080 is known to be toxic to this species (Twigg & King, 1991) with an  $LD_{50}$  of about 40 mg/kg for the South Australian population and 200-300 mg/kg in Western Australia. This discrepancy is attributed to the wildlife of West Australia having co-evolved with plants that naturally produce

sodium fluoroacetate. These toxic plants do not occur in the eastern states (Wheeler *et al.*, 1979; Twigg *et al.*, 2009). It is assumed that this exposure has equipped the Western Australian population of *V. rosenbergi* with a considerable tolerance compared to their eastern counterparts. The  $LD_{50}$  for 1080 in NSW varanids would likely be similar to that of the South Australian population given the lack of the relevant flora. It has been suggested that the use of 1080 baits be further investigated in relation to their impact on *V. rosenbergi* and other scavenger/predator species in NSW and Victoria (Anon, 2009).

The present sighting, together with records from the Atlas of NSW Wildlife (DECCW, 2010), suggests that *V. rosenbergi* is probably

**Figure 2. Photograph of the sighted *V. rosenbergi*, showing the distinctive color pattern of this species (Photo: H. Schütze)**



**Figure 3. Distinctive *V. rosenbergi* facial markings on this individual. (Photo: H. Schütze)**



**Figure 4. Monitor with prey. (Photo: H. Schütze)**



more common in the area west of the Blue Mountains than first thought. Atlas records suggest a distribution from Mudjee south to Lithgow, in the Capertee Valley and Wollemi National Park. However, these data are based upon sightings that are unsubstantiated by specimens or photographs in most cases, and no differentiation is made between substantiated and unsubstantiated records (Glenn Shea, pers. comm.). These sightings suggest a wide-spread occurrence in the region, but still leave questions of population size and relative health largely unanswered.

#### **ACKNOWLEDGMENTS**

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# BOOK REVIEW: REPTILES OF THE NSW MURRAY CATCHMENT. A GUIDE TO THEIR IDENTIFICATION, ECOLOGY AND CONSERVATION.

By Damian Michael and David Lindenmayer, 2010.  
238 pp., 170 colour photographs.  
Published by CSIRO Publishing, Collingwood, Victoria.  
R.R.P. \$39.95. ISBN 9780643098206

The production of field guides to various components of the continent's reptile fauna has been something of a growth industry in recent years, and has operated at a variety of scales. Following the production of telephone-book-sized guides to the entire continent (e.g., Cogger, 1975; Wilson & Swan, 2003) have come smaller, more regionally-based guides. The geographic basis for these regional guides has often been political boundaries (e.g., Hutchinson *et al.*, 2001; Swan *et al.*, 2004), or alternatively centres of population, (e.g., Bush *et al.*, 1995). A lesser trend is the production of guides that reflect biogeographic regions (e.g., Swan & Watharow, 2003, for the Victorian mallee; Bush *et al.*, 2007 for southwestern Australia). The latest addition to this latter group is *Reptiles of the NSW Murray Catchment*.

The geographic restriction of these smaller guides not only allows the books to be smaller and more field-friendly, but also means they deal with a smaller, more relevant range of species for regional readers. This in turn allows the authors to provide larger and more numerous photos, more biological information, and fewer and less complex keys (if keys are provided), making these guides potentially more user-friendly.

In the present case, only 80 species are dealt with. The accompanying photographs, all in colour, are of high quality and good reproduction, large size (page-width) and numerous (two per species for most taxa, often with one being a close up of the head or body). In a small number of cases, turning away of the lizard's head produces an apparent foreshortening of the snout that could confuse the inexperienced reader. Keys are avoided, and identification of most species relies on the reader flipping through the photographs and

distribution maps. To assist with identification, the species accounts begin with brief statements of diagnostic characteristics and often with comments on how to differentiate the species from similar species. To assist with the identification of small brown skinks (the herpetological equivalent of the SBBs of bird-watchers), Chapter 6 gives a series of illustrated tables and paragraphs that compare the species in six morphotypes: elongate fossorial species (5 species), *Ctenotus* (6 species), *Egernia* (3 species), *Liopholis* (3 species), *Eulamprus* (3 species) and *Pseudemoia* (4 species). These are generally useful, although the publisher's formatting can be confusing, as the tables are often distant from the relevant descriptions, instead embedded in paragraphs dealing with other genera.

The distribution maps, while large size, use varying combinations of coloured blobs and dots: 36 distributions are indicated by a regional blob; 27 only by dots scattered on the map, and 18 have a combination of a blob and one or more dots. Species with very similar distributions may have different map formats. No explanation is given for the variation.

The additional biological information for each species includes descriptors of activity site (as "life-form"), reproductive mode, activity time, distribution, shelter sites, vegetation type (a listing reinforced by a tabulation of this information in Appendix 1, and descriptions and illustrations of the habitat types in Chapter 4), conservation status (regionally rather than nationally), and two more extensive accounts, "additional notes" and "facts". The latter two headings include a variety of miscellaneous information, some species-specific, some more general, and the division into two categories is often artificial.

The final category in each species account is "management", and this gives an indication to the authors' reason for producing this book. Not only is it intended as a field guide, but also as a source of information for local wildlife managers and landowners, and it is this emphasis that makes this book unique. Conservation messages occur throughout: Chapter 2 is a justification for conservation of reptiles; Chapter 3 discusses ways of conserving reptiles on farms, and the reference list at the end is not just the usual range of general sources, but includes research papers on the ecology of the species covered and their management (many of them by the authors). The reference list is impressively up to date, as is the taxonomy, which incorporates recent revisions of *Cryptoblepharus*, *Egernia* and *Lerista*, although it does overlook the recent division of *Pseudonaja nuchalis* (Skinner, 2009), and incorrectly uses the junior homonym *Anepischetos* (under the misspelling *Anepischtos*) rather than *Anepischetosia*.

However, there are a few down sides to the book. The restriction of the book to the NSW Murray catchment, a biological region of little relevance to the distribution of most reptiles, means that a significant number of species are peripheral to the main regional focus of the book. Nineteen species are restricted to high altitudes at the extreme east of the area, a region of little relevance to landowners in the majority of the region, but conversely excluding much of the Australian Alps and hence reducing the utility of the book to users at high altitudes. An additional seven species enter only in the extreme west, where semi-arid spinifex habitats impinge on the Murray catchment; these latter species are mostly represented by single localities. The restriction of the book to a political boundary, the New South Wales side of the Murray River, means that readers in Victoria will be uncertain how applicable the information is to their half of the catchment. Also, given the strong focus on management, it would have been useful to provide information on the timing of reproduction rather than just occasional comments on clutch size.

These quibbles apart, this volume is an important addition to the genre, and should be essential reading for fieldworkers, wildlife managers and landowners.

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University of Sydney, NSW 2006.

## NOTES TO CONTRIBUTORS

*Herpetofauna* publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry and breeding.

All material must be original and must not have been published elsewhere.

### PUBLICATION POLICY

Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

### SUBMISSION OF MANUSCRIPT

Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – High resolution digital, black and white prints or colour slides are acceptable.

Use a recent issue of *Herpetofauna* as a style guide.

Manuscripts may be submitted to the editor electronically, via email (gshea@mail.usyd.edu.au) or on CD. Manuscripts submitted electronically must be in Word format, with photographs as separate jpg or tif files.

Articles should not exceed 12 typed double spaced pages in length, including any illustrations.

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Any references made to other published material must be cited in the text, giving the author, year of publication and the page numbers if necessary. At the end of the article a full reference list should be given in alphabetical order. (See this journal).

Manuscripts will be reviewed by up to three referees and acceptance will be decided by an editorial committee. Minor changes suggested by the referees will be incorporated into the article and proofs sent to the senior author for approval.

Significant changes will require the article to be revised and a fresh manuscript submitted.

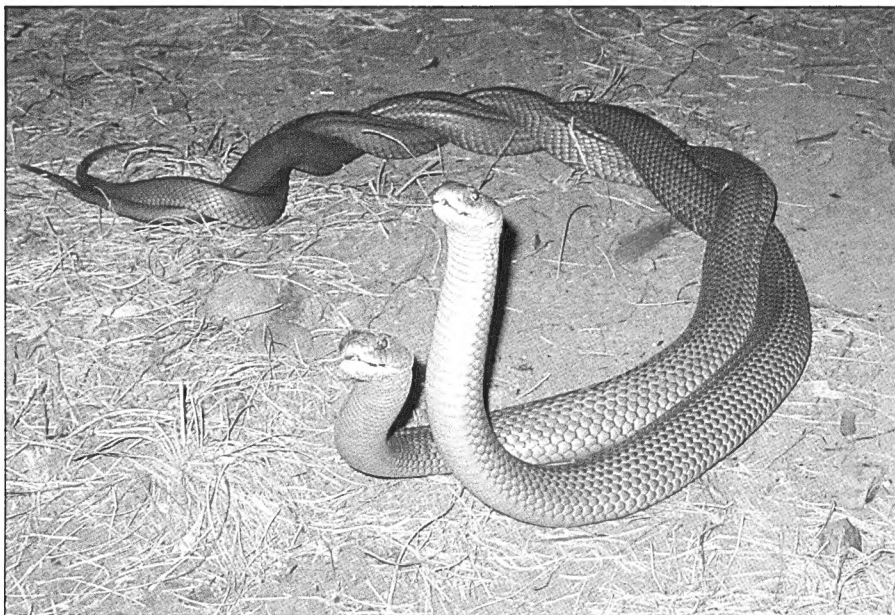
### REPRINTS

The senior author will receive a PDF copy of their article.





Heath Monitor (*Varanus rosenbergi*) from near Rylstone, New South Wales, eating a rabbit (Photo: H. Schütze). See article on this species on page 58.



Male combat by Mulga Snakes (*Pseudechis australis*) at Mornington Wildlife Sanctuary, Western Australia (photo: R. Lloyd). See article on page 16.